INTERAVIA

REVIEW OF WORLD AVIATION

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America Discovers the Caravelle

VOLUME XII 8 AUGUST 1957

THE AVRO ARROW
The name selected for the still secret AVRO CF-105 is symbolic of the pointed missile concept of this supersonic interceptor, being developed as the successor to the AVRO CF-100.
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INTERAVIA

Review of World Aviation

Volume XII **No. 8** **August 1957**

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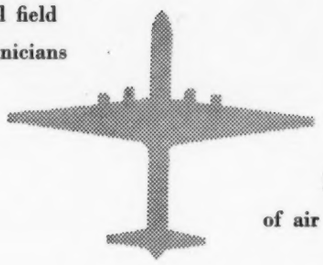
has its technicians



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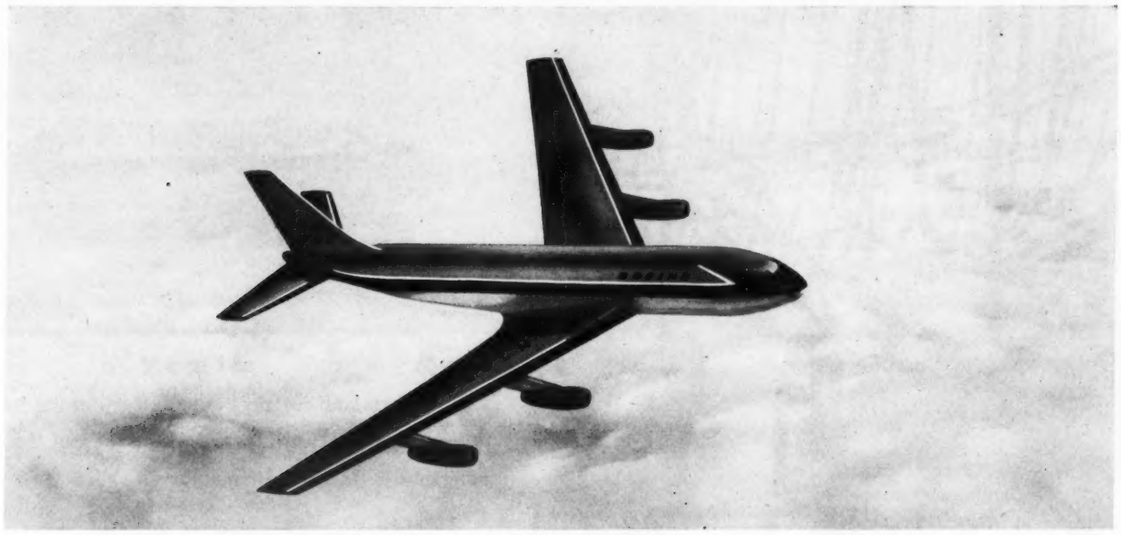
Three B-52's at altitude. More than 1400 B-52's and B-47's have been built by Boeing.

Boeing has built more long-range, multi-engine jet aircraft than any other company in the world.



The 707 jetliner — test-flown over 2½ years — will bring you all of the advantages of this Boeing experience with jet aircraft.

These airlines already have ordered 707s :

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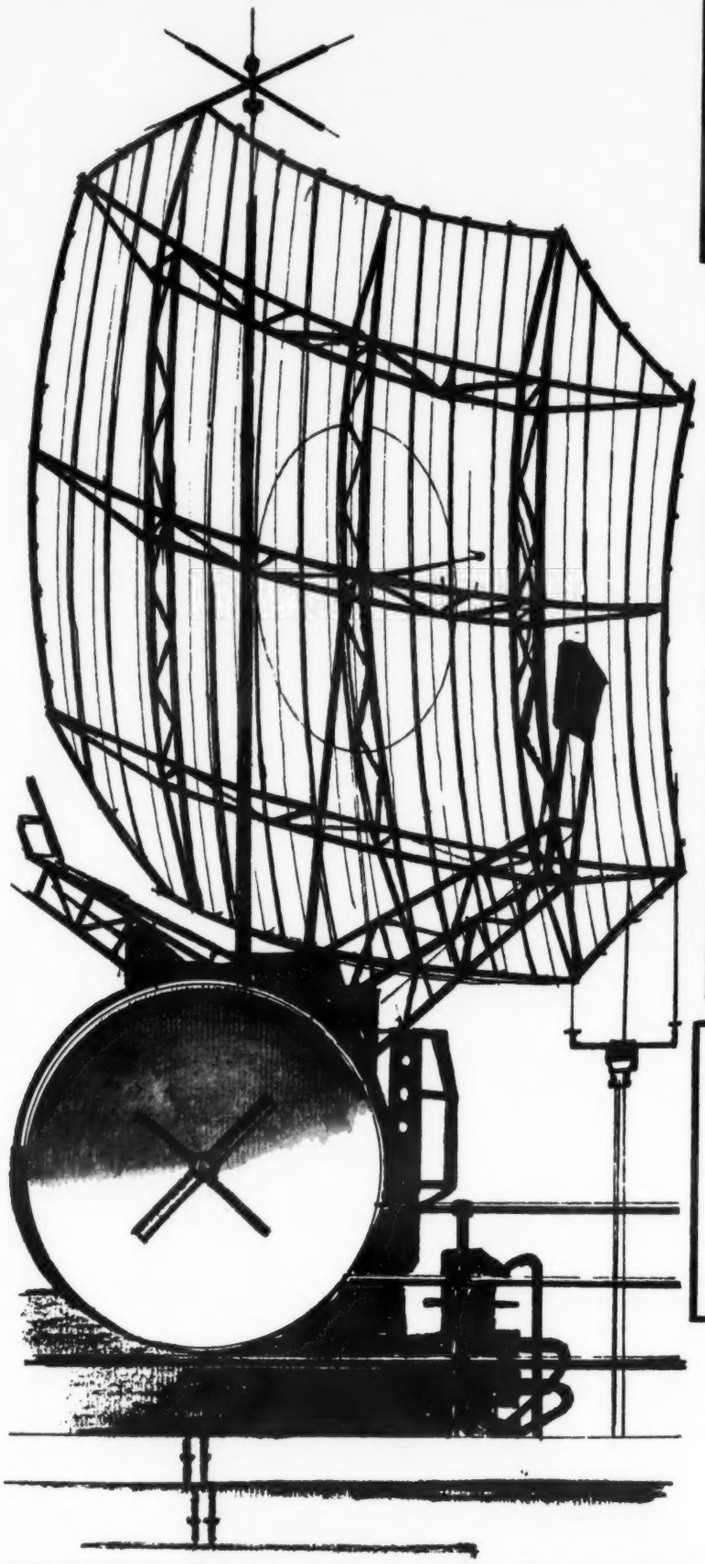
PAN AMERICAN - QANTAS - SABENA - TWA

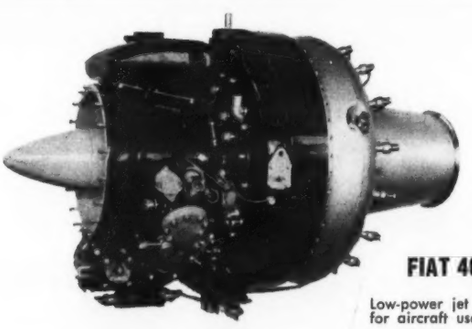
BOEING 707

FIAT AVIATION



Light tactical support fighter (N.A.T.O.).
Main advantages of this aircraft: limited dimensions, light weight, low unit cost and operating costs, ability to operate from semi-prepared fields and grass runways.

Two-seat version for advanced training in the transonic range. Retains all the basic advantages of the single-seat model (Mach 1+).



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TYPE SNW 50

TYPE S232 AIRFIELD CONTROL RADAR

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Removes ground clutter which obscures aircraft response by means of an extremely efficient moving target indicator (M.T.I.) system which feeds only echoes from moving targets to the display.

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STORM WARNING RADAR

Storm Warning Radar can now be recognised as an important element of an Airport Surveillance and Control system.

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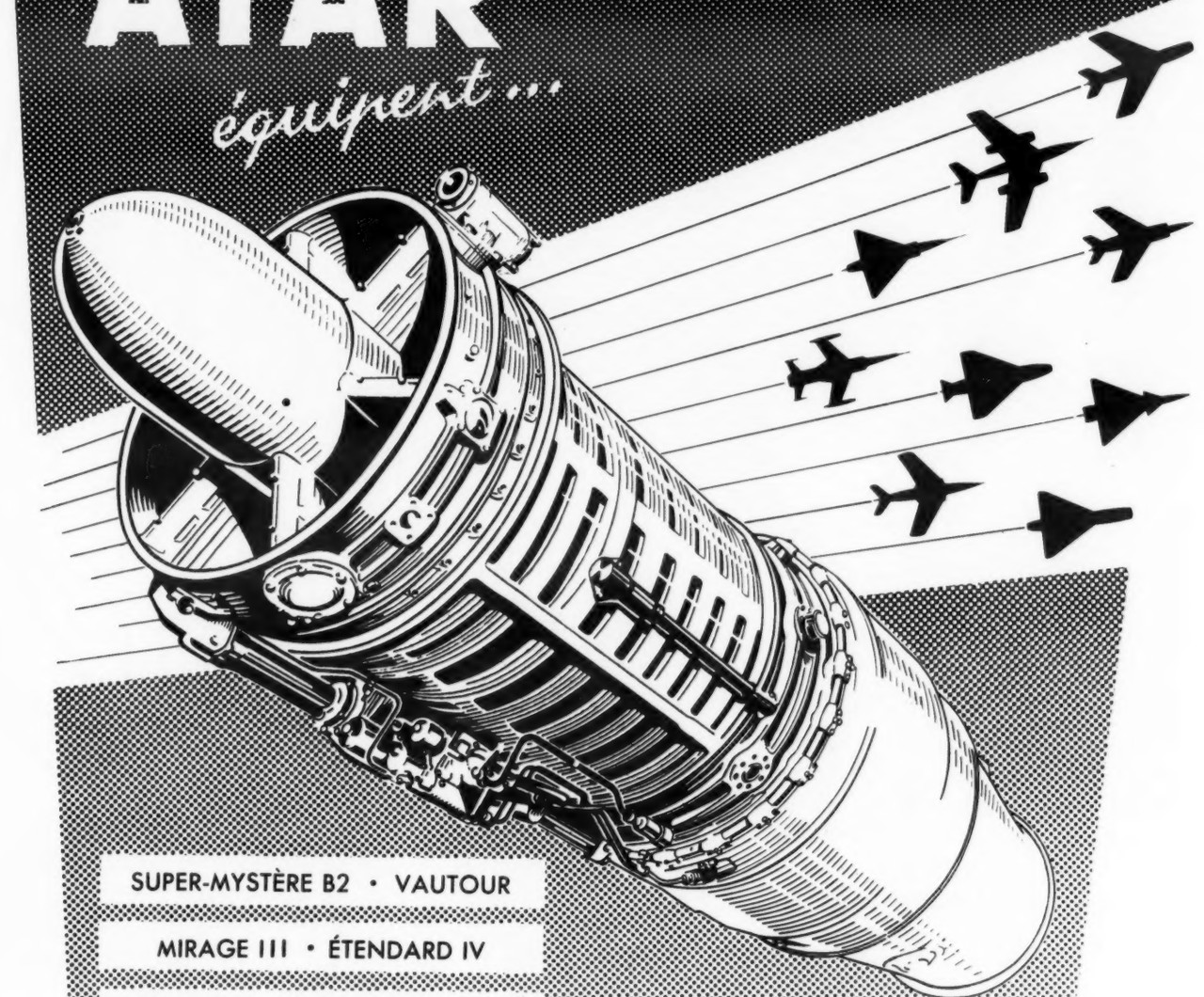

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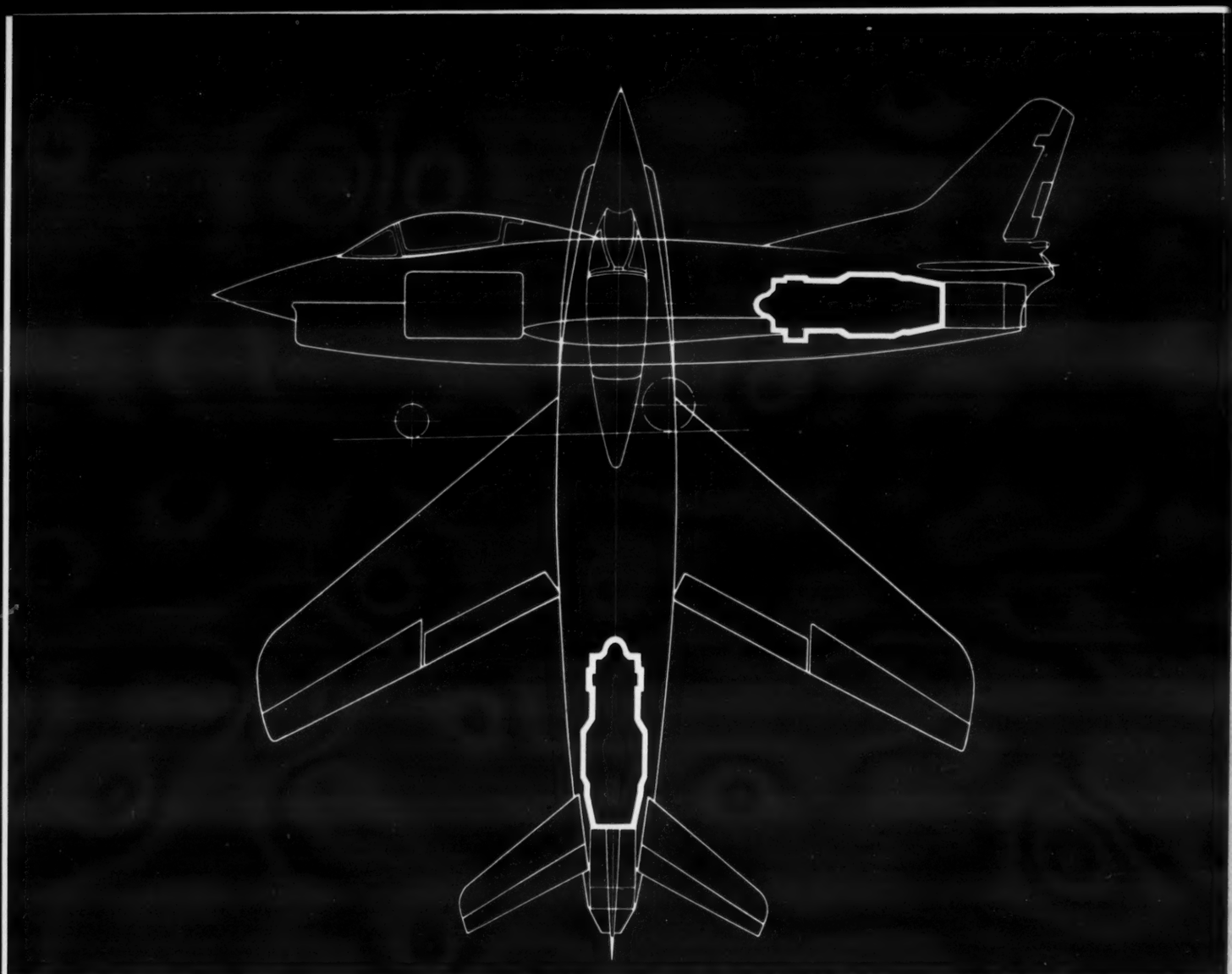


Which came first, the **engine** or the **aircraft**?

In the case of the Fiat G 91 the answer is straightforward. Fiat's engineers were able to start the G 91 project because there was available a lightweight turbojet which satisfied exactly their design requirements. This engine was the Bristol Orpheus. The Orpheus itself had been initiated as a design project only two years earlier.

Objectives of the Bristol Orpheus project...

To produce a simple, lightweight turbojet engine of exceptional power/weight ratio suitable for the new generation of lightweight fighters, and also for trainers, transports and executive aircraft. The engine had to be low in cost and easy to manufacture and maintain.

Development progress

A year after detail design began, the first Orpheus engine was running. Six months later, an official 150 hours type test had been completed and the engine cleared for flight. In July 1955 the first Orpheus-powered aircraft took the air.

This unprecedented speed of development was largely due to the thinking on lightweight turbojets which already existed when the Orpheus project was initiated, combined with the enormous fund of experience amassed at Bristol on turbine engine design.

Current position

The Bristol Orpheus B Or 2 last year completed a declared type test at a static thrust of 4,520 lb. Now the Orpheus B Or 3 has been type tested at 4,850 lb, for a weight of 810 lb, giving a thrust/weight ratio of 6:1—higher than that of any other type-tested engine. Still more powerful versions are under development, including the recently announced B Or 12 of 6,810 lb thrust.

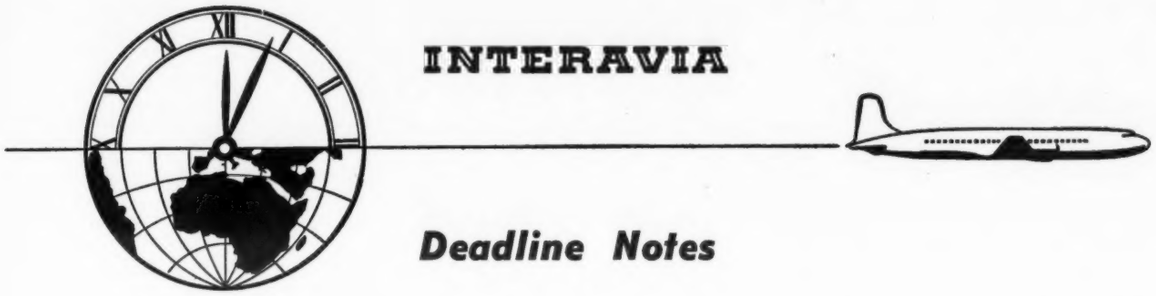
The Orpheus powers the Folland Gnat, the Fiat G 91 and the Dassault Etendard VI, all of which have flown ; it is specified for the French Breguet 1001 Taon which will fly shortly ; also for the Italian Aerfer Leone, the Japanese Fuji TIF 1 trainer, the Spanish Hispano HA 300 lightweight interceptor, and a number of other new aircraft.

Development potential

Now that the Orpheus is a proven engine with thousands of bench and flight hours behind it, many more roles await it . . . in fighters, strike aircraft, trainers, transports, and mixed power aircraft.

Simple to make, operate and maintain ; astonishingly light in relation to its power ; with scope for reheat and reverse thrust, the Orpheus is a typical example of the creative thinking and care that go into the design of all Bristol engines.

BRISTOL
Aero-Engines



INTERAVIA

Deadline Notes

No. 8, 1957

● **The programme for the 13th Annual General Meeting of I.A.T.A.** includes a public plenary session in the Auditorium of the Instituto Nacional de Previsión, Madrid, on September 9th with welcoming speeches by representatives of the Spanish Government and the City of Madrid. Dr. Tomas Delgado Perez de Alba, President of Iberia, will take office as President of I.A.T.A. for 1957-58, succeeding Lord Douglas of Kirtleside, Chairman of British European Airways. Sir William P. Hildred, I.A.T.A. Director General, will submit his annual report on the state of the world air transport system. On Monday evening delegates will be received by the Spanish Air Minister, General Dias de Lecea. — The closed sessions of the Standing Committees, to be held at the Gaylord Hotel, will deal primarily with the forthcoming introduction of turbine-powered aircraft, the proposed introduction of new low-fare services on important world routes, and the effects on the airline economy of rising costs of operation. At the closing public session, scheduled for September 13th, formal resolutions of the Meeting will be presented for final consideration and voting. A new President, to take office at the 1958 General Meeting, will be elected and a place for that session chosen.

● **Air talks between the United States and Belgium** were suspended on July 23rd following American opposition to a Belgian request for a new air route to San Francisco. State Department officials said the opposition came from Pan American World Airways and Trans World Airlines, which had recently been licensed to fly this route. It was also announced that the State Department had agreed to a resumption of the negotiations in Brussels this autumn. In the meantime, civil aviation experts of the two countries are likely to meet in Washington or Brussels to continue the technical side of the talks and to make a useful preparation for the Brussels meeting.

● **P.A.A. and T.W.A.** have been authorized by President Eisenhower to operate polar routes between the West Coast of the United States and Europe. The permanent route awarded uses Los Angeles and San Francisco as co-terminals. P.A.A. has also obtained permission to include Portland and Seattle in its Polar route for a two-year period. T.W.A. will begin operations this autumn, and P.A.A. as soon as the necessary equipment is available.

● **El Al Israel Airlines** is due to resume its weekly Tel Aviv-Johannesburg *Constellation* service on September 1st. The service was suspended at the beginning of June when the contract with Union Aéromaritime de Transport to operate it under charter ended. U.A.T. had operated the service for 18 months, after El Al had difficulties in maintaining its South African flights following the loss of a *Constellation* over Bulgaria in July 1955. Now that El Al has received the first of its four *Britannias*, the equipment position has eased. — The Johannesburg service will later be operated by *Britannia*.

● **Air France** expects to take delivery of its first three *Caravelles* towards the end of 1958 and will immediately put them into service on its European and North African network. The remaining nine will be delivered in the course of 1959 and 1960. It is considered virtually certain that the company's option on an additional 12 *Caravelles* will be taken up.

● **The third five-year plan** for the expansion of the three airports administered by the Paris Airport Authority—Orly, Le Bourget and Issy-les-Moulineaux—calls for an expenditure of 34,000,000,000 French francs. The following construction work is envisaged for 1957-58 : *Orly*—relocation of Route Nationale No. 7, construction of road bridges, ground work on the new terminal building and erection of steel scaffolding, extension of runway No. 4 to 10,000 ft. and widening of the parking area. *Le Bourget :* a new hangar is to be built for Union Aéromaritime de Transport and Société d'Exploitation et de Constructions Aéronautiques.

● **Cologne-Wahn Airport** was officially handed over to the German authorities on July 18th by Air Vice Marshal Hogan of the Royal Air Force. Major General Plocher, head of the Air Force Command Staff, took over the airport's military installations on behalf of the German Air Force. Civilian installations and airport facilities will be operated by the Ministry of Transport.

● **Dr. Kurt Knipfer,** head of the Aviation Department, Federal German Ministry of Transport, has retired and been replaced by Ministerial Director Heinz Kallus.

● **Development of the SM-64 Navaho** intercontinental guided missile has been cancelled by the U.S. Air Force. According to a North American Aviation spokesman, cancellation of the contract came as a " bolt out of the blue ". Although the full effect cannot immediately be assessed, early predictions are that upwards of 10,000 administrative, engineering and production employees will be cut from the payroll. The first step has been the dismissal of 6,300 workers, and company officials are apprehensive that they may be forced to close down the entire missile development operations at Downey, Calif. Subcontracts to the value of $35,000,000 have already been cancelled. — The *Navaho* had been under development at North American Aviation since 1946.

● **Douglas Aircraft Co.** has been awarded a U.S. Air Force contract valued at $38,869,715 for the production of C-133 military transports.

● **Republic Aviation Corporation** has stated that it is " very probable " that it will exercise its option to produce the Sud-Aviation *Alouette II* helicopter in the United States. A final decision is to be made this month.

● **Convair-Astronautics** began moving into its new $40,000,000 *Atlas* I.C.B.M. plant on the outskirts of San Diego late last month. Complete occupancy is expected by January 1958.

● **Piper Aircraft Corporation** is stepping up its research and engineering programme with the establishment of a new development facility at Vero Beach, Florida. To be known as the Piper Aircraft Development Center, the Florida facility will be devoted to the design, construction and test flight of experimental prototypes of future aircraft to be marketed by Piper. Eventual establishment of a complete plant at Vero Beach for the production of certain Piper models is contemplated.

From INTERAVIA's world-wide news service, including INTERAVIA AIR LETTER, the daily international aviation news digest. — No part may be reproduced without written permission.

● **Canadian Thermo Control Co. Ltd.** is the ninth addition to the A.V. Roe Canada group. The new company will sell and service refrigeration equipment for trucks and trailers, railway freight cars and tanks, buses and ships under licence agreement with the Thermo King Railway Corp., of Minneapolis. — Crawford Gordon Jr., President and General Manager of A. V. Roe Canada Ltd., will be Chairman of the Board of the new company. A. C. MacDonald, President and Managing Director of Canadian Car Co. Ltd., will be President and a Director.

● **The English Electric P.1** all-weather interceptor has unofficially broken the world aircraft speed record of 1,132 m.p.h. previously held by the Fairey Delta 2. The actual speed reached is being kept secret. The company says that as the flight was not made under record conditions, no official record can be claimed.

● **Compagnie Française Thomson-Houston** and **Decca Radar Ltd.** have concluded an agreement to cooperate in the design and production of radar equipment for European air defence under the N.A.T.O. programme. The two companies will make available to each other design details of certain types of equipment and will split up among them production of certain parts.

● **S.N.C.A. du Nord** has received an order from West Germany for 1,000 SS. 10 anti-tank missiles, for use by the German Army.

● **Dornier Werke** is producing Do 27 liaison aircraft at the rate of eight per month at its Munich-Neuaubing plant and hopes to increase this rate to 15 monthly by October. This average will then be maintained until the current Defence Ministry contract for 469 aircraft is filled.

● **A 100,000 man cut in the armed forces** of the United States, to be carried out within the next six months, has been approved by President Eisenhower. According to Defense Secretary Charles E. Wilson, the reduction will result in savings of approximately $200,000,000. Army personnel will be reduced by 50,000 men, and Air Force strength by 25,000 men, with the Navy's reduction quota set at 15,000 and the Marine Corps' at 10,000.

● **The Italian Air Force** is to be entirely re-equipped during the 1957-58 budget year. Republic F-84G fighters and reconnaissance aircraft will be replaced by F-84Fs and RF-84Fs, the D.H. *Vampires* by Canadair F-86Es, D.H. 112 *Venoms* by North American-Fiat F-86Ks, and Lockheed PV-2 anti-submarine aircraft by Grumman S2F-1s. The sea rescue service will be equipped with Grumman S-16s and Sikorsky H-19Ds. New warning equipment will be procured to enable Italy to be included in the military radar network extending from Norway to Turkey. Army aviation units are to receive several hundred aircraft, and a special helicopter unit will be maintained. The first tactical parachute group has been set up by the Army. — United States military aid to Italy during the coming six months is expected to total 130,000,000,000 lire : aircraft (70,000,000,000 lire), equipment for three *Nike* battalions and one *Honest John* battalion (45,000,000,000 lire), ground facilities and special training courses (15,000,000,000 lire). From 1951 to 1956, American military assistance to Italy totalled 1,000,000,000,000 lire.

● **The French Navy** has signed a contract with Ateliers d'Aviation Louis Breguet for 100 Breguet 1050 *Alizé* anti-submarine aircraft.

● **West Germany's Northern Air Defence Command,** which will be established at Münster, Westphalia, on October 1st, 1957, is expected to be headed by former Lieutenant General Harlinghausen, who re-joined the Air Force on August 1st with the rank of Major General. A Southern Air Defence Command is also likely to be set up with headquarters at Karlsruhe.

Workshop Briefs

• A Douglas MB-1 *Genie* air-to-air rocket with atomic warhead was fired from a Northrop F-89 *Scorpion* jet fighter over Yucca Flat, Nevada, atomic test site on July 19th. Released from the parent aircraft at an altitude of 20,000 ft. to 30,000 ft. by means of command signals transmitted from the ground, the weapon was detonated in the airspace ahead of the aircraft.

• Fuels based on aluminium-trimethyl and aluminium-triethyl, which ignite spontaneously on contact with the air, are being tested by Curtiss-Wright for possible use to re-ignite jet engines that have flamed out at altitude. Ground tests in the pressure chamber have proved that, after injection of small quantities of these so-called "pyrophoric" fuels, jet engines can be re-ignited at altitudes of up to 52,000 ft.

• The Westinghouse J54-WE-2 jet engine has a one-piece 16-stage axial compressor of moderate compression ratio and a 2-stage turbine. Built largely of titanium, the engine delivers a thrust of 6,200/6,500 lbs.

• The low-noise Curtiss-Wright TJ38 jet engine is equipped with a thrust reversal device and bears the designation *Zephyr*. Further details : twin spool compressor system, with seven high and five low-pressure stages, driven by two separate turbines ; overall compression ratio 10.5 :1 ; annular combustion chamber, with eight flame tubes ; dry weight 3,600 lbs.

• A U. S. Navy's Chance Vought F8U-1 *Crusader* supersonic fighter, piloted by Major John H. Glenn, set up a new speed record on July 16th for a west-east crossing of the North American continent. He covered the 2,460 miles from Los Angeles to New York in 3 hrs. 23 mins. 8 secs. at an average speed of 630 knots.

• The speed of the Convair B-58 *Hustler* supersonic bomber is 1,120 knots, it was revealed recently by Convair Chief Engineer Frank W. Davis. Though the B-58 would be capable of reaching speeds of around 1,320 knots or roughly Mach 2.3 at altitudes of over 33,000 ft., such speeds are not permitted at present because of the excessive airframe heating which would result.

• The Westland *Wessex* helicopter, which is designed primarily for anti-submarine operations, sea rescue, communications and ambulance duties, has a top speed of more than 120 knots and a range of approx. 360 nautical miles with a fuel supply of 300 gals. Max. rate of climb is 1,650 ft./min., and max. hovering ceiling without ground effect 5,000 ft.

• Hamburger Flugzeugbau G.m.b.H. has designed a twin-turboprop commercial transport designated HFB-209. The aircraft is designed for short and medium stage traffic and is to be capable of carrying some 48 to 54 passengers over block distances of up to 1,085 nautical miles. Fitted with two Napier *Eland N.El.6* turboprops, the HFB-209 is destined to operate at altitudes of around 20,000 ft. at a cruising speed of 277 knots.

• "Design 159" is the name of a new turboprop businesss aircraft, with two Rolls-Royce *Dart* engines, announced by Grumman Aircraft Co. First production models will be ready for delivery in May 1958 and will offer accommodation for up to 12 passengers in a pressure cabin ; max. range 1,900 nautical miles.

• The Soviet Union is reported to have a new medium bomber with sharply swept wings and four jets grouped in pairs on either side of the fuselage above and below the wing roots. The aircraft would appear to be a successor to the twin-jet *Badger*.

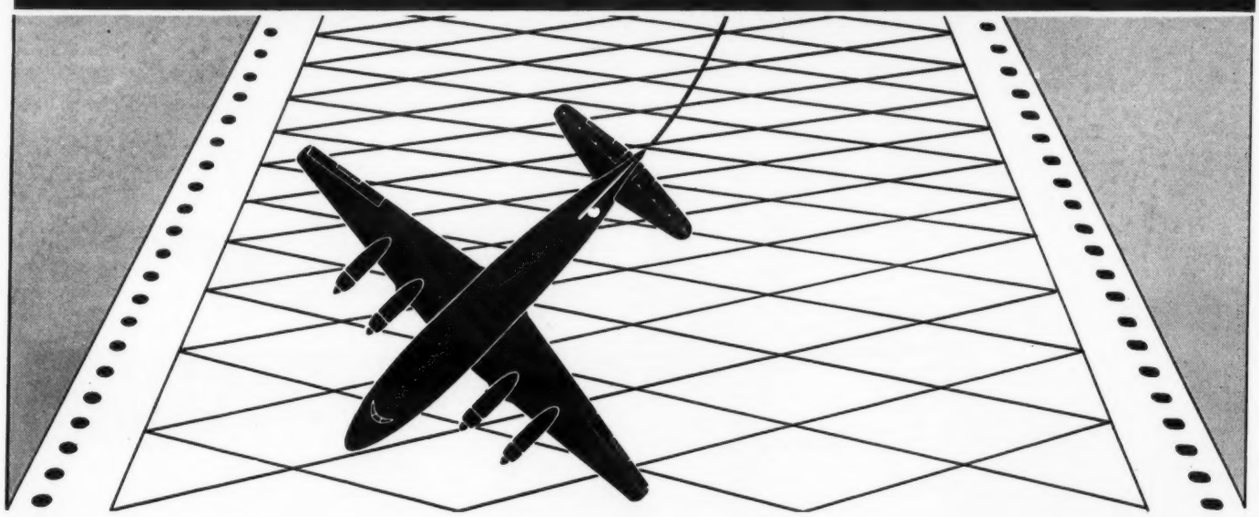
• Four new Soviet commercial transports were shown to the public for the first time at Moscow's Vnukovo Airport on July 10th. 1 - An improved version of the Tu-104 with the new designation Tu-104A and accommodation for 70 passengers ; max. speed 540 knots.

2 - Tu-110 four-jet long-range transport for 78 or 100 passengers ; max. speed approx. 540 knots ; range roughly 2,000 nautical miles.

3 - The Antonov *Ukraina* four-turboprop aircraft, with 4,000 s. h. p. NK-4 engines ; range with 84 or 120 passengers roughly 2,000 nautical miles.

4 - A four-turboprop transport for 75 or 100 passengers, designated Ilyushin Il-18 *Moskva,* also fitted with NK-4 propeller turbines designed by N.D. Kuznetsov. Max. payload 14 tons ; payload for range of 2,700 nautical miles roughly 8 tons ; gross weight 58 tons.

Situation under control



The Decca System is fast becoming an integral part of the entire field of aviation. The Traffic Controller in particular has his task immeasurably lightened when Decca fitted aircraft fly on pre-determined tracks, and their pilots are able to follow instructions precisely. For the first time he can integrate aircraft of all types —fixed wing or rotary, turbo-prop or jet, into a single air traffic control plan. Decca fitted aircraft navigating accurately with reduced separation standards enable him to make the greatest use of the limited controlled air space. He can do so because Decca is the only system accurate enough to ensure that aircraft *can* fly on track, on schedule, at all altitudes, in all weathers, over every kind of terrain. Decca tracks and reporting points have been established in the London F.I.R. since July 1956, and are now being introduced at Frankfurt. Now that Dectra, the long range navaid for the North Atlantic, is on the air, the day when all the air routes of the world will be Decca flown comes nearer. Then indeed the situation will be under control.

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Brief technical specifications

The AERO SUPER is a cantilever twin-engined low-wing monoplane with an enclosed cabin accommodating the pilot and three passengers. It is powered by two Walte Minor 4-III engines of 105 b.h.p. each, with type V 401 electrically controllable pitch propellers. Its range is 1500 km, its fuel consumption rate being 50 litres per hour.

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CONTRAVES ITALIANA S. p. A. ROMA

CONTRAVES has been supplying gun directors for 11 years; they are used in 11 Countries both by Army and Navy.

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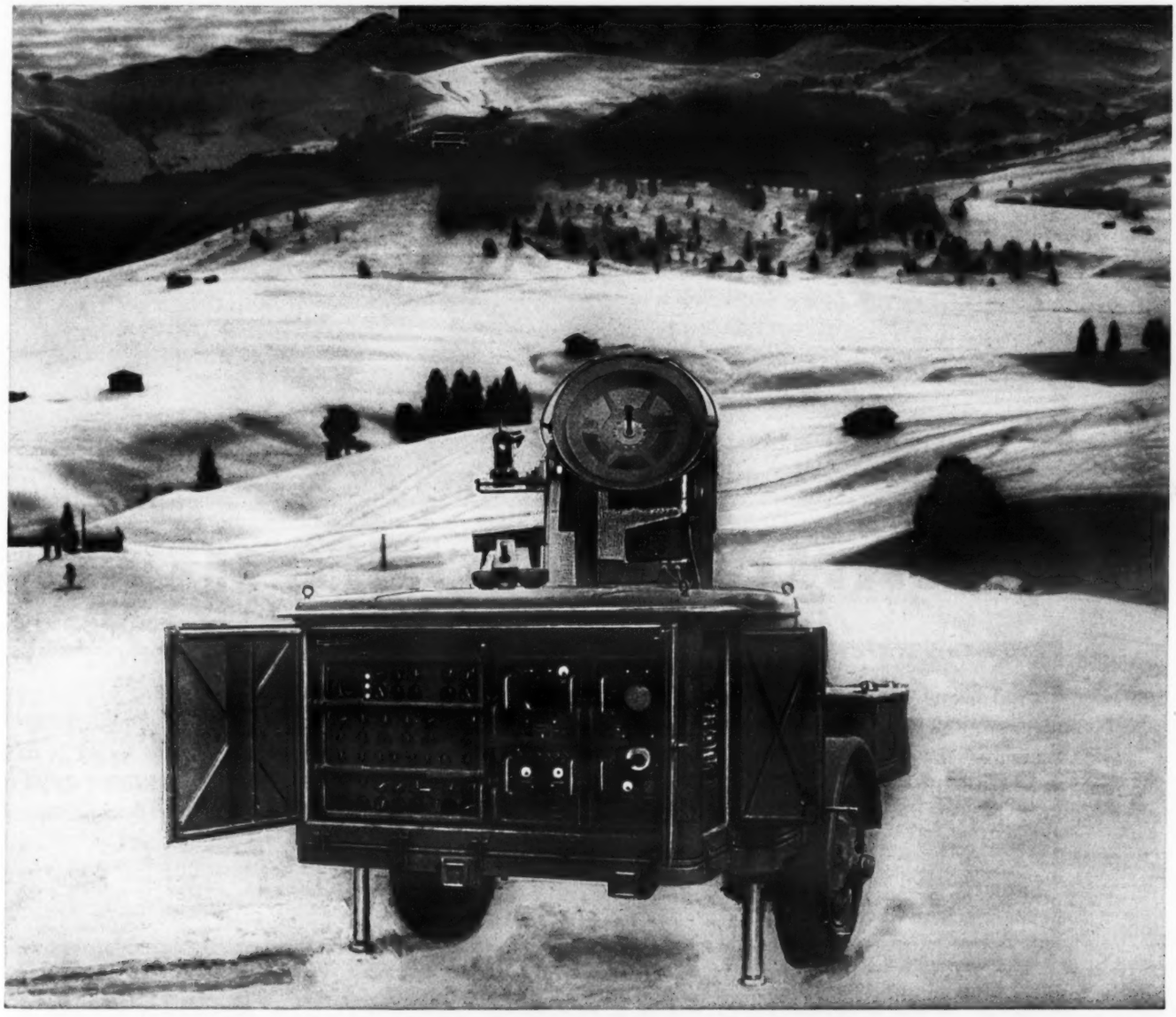
while operating at very low temperature.



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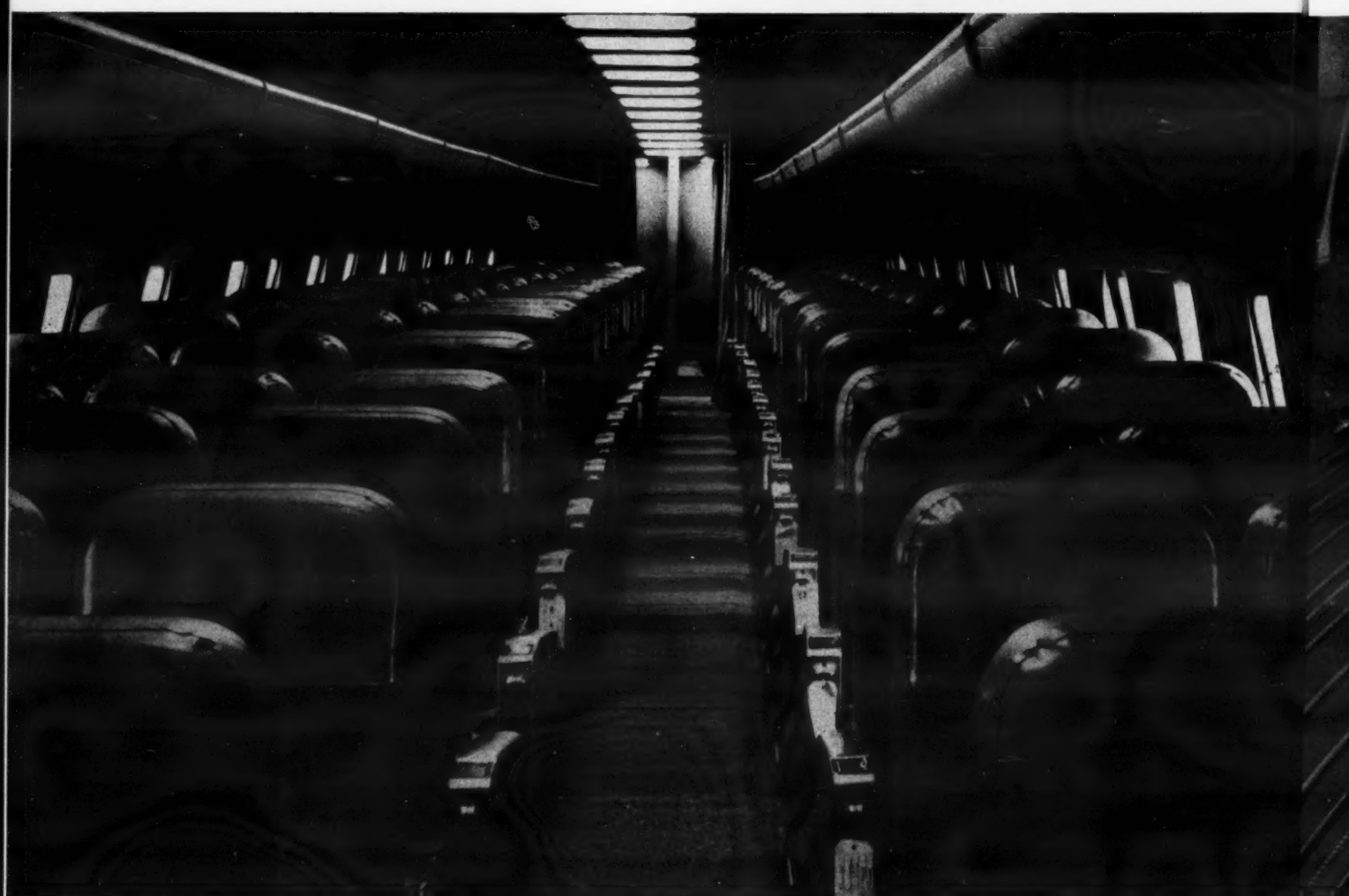

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Photo J. BUTLE

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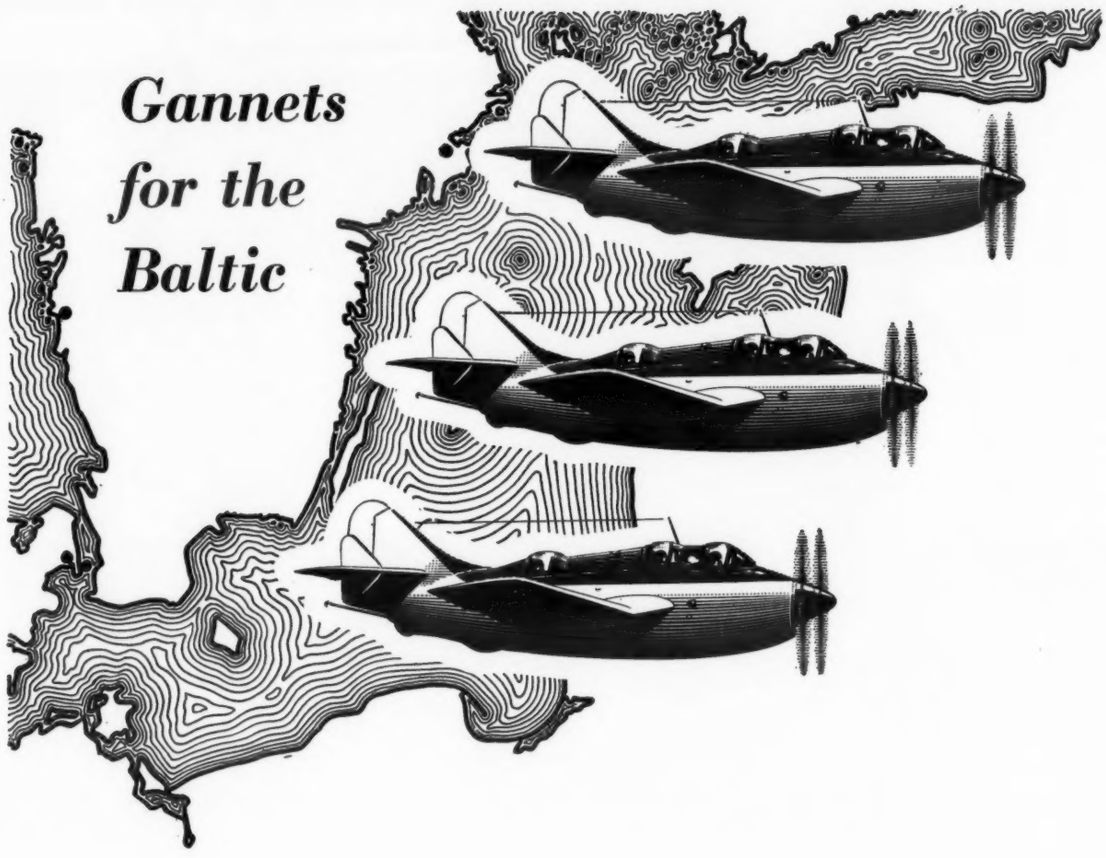

WESTERN GERMANY has ordered Fairey Gannet anti-submarine aircraft for its shore-based Naval Air Arm. The Gannets, combining in a single aircraft the ability both to search *and* strike with long endurance and the most comprehensive search radar, will provide anti-submarine cover in the Western Baltic. Thus one more is added to the long list of seas and oceans under Gannet anti-submarine surveillance.

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Powered by the Armstrong Siddeley Double Mamba

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New York Finance Notes...

U.S. Airlines and Aircraft Industry in Mid-July 1957

by Scott Hershey, New York

A throttling down of military spending with emphasis on aircraft and related items is in prospect with the beginning of the Government's new fiscal year.

The extent of the spending surge which officials are trying to bring under control is pointed up by the final figures for the fiscal year just ended which will show total defense outlay of about $38.5 billion, or $2.5 billion over estimates. The surge was laid in part to unforeseen success of the missile program, necessitating speedier delivery of components, and an unexpected speed-up in the deliveries of aircraft. Such items must be paid for promptly. One cause of the spending surge that the Pentagon can't do much about, of course, is the increase in wages and prices, with the recent steel price rise as a case in point. Such costs automatically are passed along to the military under existing contracts and also are reflected in new contracts.

One of the first moves of the economy drive will be a stretch-out of existing programs. Just which ones will be affected is not known at this time, but certain fighter planes, both for the Navy and Air Force, could be affected. Less advanced models for which replacements are in sight also could be vulnerable.

There are hints, too, of further contract cancellations. But rather than cancel current production, Pentagon officials prefer to weed out unnecessary items from future hardware under development. The Navy, for example, just recently cut out new planes under development by Douglas and Lockheed.

Defense contractors at a recent meeting were told by Secretary of the Air Force Douglas that there are too many systems now in the stage of testing and there seems to be in particular a multiplicity of missiles. The Pentagon already has said it will settle on one missile in each range, but the economy push may force this decision earlier than expected.

The ballistic missile program is due for close scrutiny, since five of this type are under development and some have been fire-tested. In the 5,000-mile inter-continental range are the *Atlas*, built by Convair Division of General Dynamics, and the *Titan*, under development by The Martin Co. In the 1,500-mile range are the Army's *Jupiter* developed by Chrysler Corp., the Air Force's *Thor* built by Douglas, and the Navy's *Polaris* on which Lockheed is the principal contractor. (*)

That there is duplication in the missile family is fairly apparent since there now are 28 publicly announced members, including about 10 in operational use. The Army's *Nike-Hercules*, built by Douglas, and the Navy's *Talos*, built by Bendix Aviation, both perform anti-aircraft missions and have approximately the same range. The Navy and Air Force have separate air-to-air missiles, the Navy's *Sparrow* and *Sidewinder* and the Air Force's *Falcon*.

The economy drive, naturally, is running into opposition within the individual services. Worries over procurement cutbacks center in the Air Force which is scheduled to spend $7.3 billion on hardware alone in the fiscal year just begun.

Obviously in order to reduce expenditures some drastic action will be necessary. Secretary Douglas estimated the Air Force alone will have to eliminate between $1 billion and $1.2 billion of expenditures, mostly in procurement, in the new fiscal year in order to hold total outlays to a $17.6 billion spending ceiling.

There is concern over the fact that stretch-outs of production tend to raise the unit cost of the weapon involved. Secretary Douglas had told Air Force suppliers that there are some programs stretched out pretty far already and that "we are going to be faced with some very high unit costs if we don't build what we would regard normally as an economic rate of production."

Last March the Air Force cancelled development work on the Douglas C-132, giant cargo plane with a 50-ton payload on long range missions up to 3,500 miles. Growing concern over spending, at least in part, prompted the spring stretch-out of Boeing's B-52 jet bomber and Boeing's KC-135 jet tanker, plus stretch-outs or cutbacks in procurement of the Lockheed F-104, the Republic F-105 and the Convair F-106, all fighter planes of the Century Series in the 1,000-mile-per-hour class. And more recently the Navy cut from 30 to 24 the number of Martin *Seamaster* P6M-2 jet-powered seaplanes.

★

The activities of Howard Hughes always arouse interest, and no exception was the recent announcement that he had purchased 15 Vickers *Viscount* four-engine turboprop airplanes for $12 million after spending five days in Montreal flight-testing the aircraft. The 15 *Viscounts* are part of the original order for 75 placed by Capital Airlines.

Of no less interest is the persistent rumour that Hughes is making plans to manufacture the French twin-jet *Caravelle* at his Culver City, Calif., plant which currently is operating at about 50 per cent capacity. Both *Viscounts* and the *Caravelles* are expected to be used on domestic flights of TWA of which Hughes is the principal stockholder.

Briefs

Capital Airlines seems to be cashing in on its *Viscount* investment through operating economies. Operating profit for May was around $600,000 and for June approximately $1 million... In view of the current depressed price levels, Northwest Airlines is regarded by some Wall Streeters as a good speculative value. It appears the company will be in the black from first half operations, after reporting a loss of 55 cents per share in the traditionally poor first quarter. This loss excluded 19 cents per share gain on the sale of equipment. Recent price was 14, slightly above the 13 3/8 low for the year and under the 17 5/8 high... Airline stocks generally moved in a narrow range, with no outstanding performers. Aircrafts were depressed by news of possible cutbacks, cancellations and the general economy drive. They rallied later, but in most cases had difficulty holding gains...

Vertol Aircraft has received an order from the Swedish Navy for four Vertol 44 helicopters, a 22-place aircraft... Fairchild Engine and Airplane says that Rolls Royce RDa 7, a prop-jet engine, has been made available for the Fairchild F-27 (Fokker *Friendship*) transports and will be used first on an order for three planes for Wien Alaskan Airlines... United Airlines started a second non-stop DC-7 custom coach flight between New York and Chicago... The Air Force decided that fewer production facilities will be needed in the future and meanwhile suggested that suppliers cut overtime and take further steps to hold spending down. Companies were urged to trim their engineering departments and aim for simplicity of design of military hardware and standardization of equipment.

(*) Mention should be made here of another far-reaching economy measure: in mid-July the U. S. Air Force ordered suspension of development work on the North American SM-64 **Navaho** long-range missile (ramjet plus rocket motor), stating that it had not yet reached the production stage and would be out of date before it could become operational. The Northrop SM-62 **Snark** long-range missile, however, is to continue in production. — The total already spent on development of the **Navaho** is estimated at $ 500,000,000. North American has dismissed 6,300 workers and fears it may have to close down the Downey, California, plant altogether. — Ed.

INTERNATIONAL MEETINGS AND CONFERENCES

Aug. 5-10th : IAS - National Naval Aviation Meeting. San Diego.

Aug. 18-25th : FAI - Yugoslavia : " Coupe Adriatique " International Parachute Contest (Union Aéronautique de Yougoslavie). Tivat-Boka Kotarska (Montenegro).

Aug. 20th-Sept. 20th : 26th International Fair. Izmir.

Aug. 22nd-27th : World Interplanetary Congress. Geneva.

Aug. 30th : FITAP - Fédération Internationale des Transporteurs Aériens Privés - Executive Committee Meeting. Le Bourget, Paris.

Sept. 1st-5th : International Autumn Fair. Frankfurt.

Sept. 1st-8th : Autumn Fair. Leipzig.

Sept. 1st-15th : RAeS IAS : 6th Anglo-American Aeronautical Conference. London & Folkestone.

Sept.1st-22nd : 22nd International Fair. Thessaloniki.

Sept. 1st-30th : 4th International Fair. Damascus.

Sept. 2nd-8th : SBAC - Society of British Aircraft Constructors Exhibition and Flying Display. Farnborough.

Sept. 2nd : IATA - Legal Committee. Estoril *.

Sept. 5th : IATA - Executive Committee. Madrid.

Sept. 7-25th : 21st International Levante Fair. Bari.

Sept. 8th : Stuttgart Aviation Day (with Industrial Show on Sept. 7th). Stuttgart.

Sept 8-15th : 66th International Autumn Fair. Vienna.

Sept. 9th : IATA - 13th Annual General Meeting. Madrid.

Sept. 9th-13th : USAF 3rd Annual World-Wide Conference of Flying Safety Officers. San Bernardino, Calif.

Sept. 10th : ICAO - Communications Division, 6th Session. Montreal.

Sept. 10th : ICAO - Legal Committee, 11th Session. Tokyo.

Sept. 13th : IATA - Executive Committee. Madrid.

Sept. 14-29th : INTERBAU 1957 - Industrial Exhibition. Berlin.

Sept. 15-24th : European Machine Tools Exhibition. Hanover.

Sept. 17th-19th : 29th USAF - Industry Conference. Santa Barbara, Calif.

Sept. 21st-22nd : " Leonardo da Vinci " Biannual Franco-Italian Aeronautical Conference. Milan.

Sept. 23rd-25th : ASME - American Society of Mechanical Engineers, Fall Meeting. Hartford, Conn.

Sept. 24th : IATA - Composite and Joint Meeting of Traffic Conferences. Miami.

Sept. 24th : IATA - Traffic Conference I (Agency Sub-Committee). Miami.

Sept. 24th : IATA - Atlantic Commodity Rates Board. Miami.

Sept. 24th : IATA - European Creative Fares Board. Miami.

Sept. 24th-Oct.15th : WMO - 9th Session of Executive Committee. Geneva.

Sept. 26th-Oct. 6th : 7th International Engineering Show. Turin.

Sept. 28th-Oct. 6th : Autumn Fair. Graz.

Sept. ... : International Fair. Bangkok.

* Provisional.

B.O.A.C. wins fight for C.A.A.

The question of the take-over of Central African Airways' external services has been one of the most hotly fought of the wordy battles which flare up from time to time in the cold war between the British Airlines Corporations and the independent operators. In the case of C.A.A. the competitors were B.O.A.C. and Hunting Clan, and it is now known that B.O.A.C. has triumphed.

If Hunting Clan had been successful, and had taken over C.A.A.'s route to London, the situation would have arisen whereby an independent company would have been running modern equipped services on a competitive basis against a nationalized corporation ; and this would have been achieved without contravening the British regulations which are intended to stop them doing just that. A Hunting Clan victory would therefore have provided a situation well worth watching, but, for good or ill, we are not to be entertained with the fascinating spectacle of a pitched battle developing between B.O.A.C. and the shipping interests backing the independent operator.

B.O.A.C. has been attacked from many angles in the British press and mainly over the financial side of the transaction whereby C.A.A. has been guaranteed a minimum profit of £1,750,000 over the ten years covered by the agreement. Hunting Clan describes this as " uncommercial ". In fact it is clear that B.O.A.C. is quite certain that the C.A.A. deal is going to make money for them and rumours put the B.O.A.C. estimates of the turnover at £50,000,000 for the ten years.

This is the first stage in a B.O.A.C. expansion programme which will probably bring further similar agreements, as several Commonwealth airlines are beginning to feel the pinch on external services as costs rise and the price of competitive new equipment goes up into the £2,000,000 per item bracket. They will be only too glad to shed their loads on to B.O.A.C. in return for fat guaranteed profit cheques ; for its part B.O.A.C. will be able to make maximum use of the tremendous fleet which it now has on order, and the possibility of linking up several new routes with good passenger potential should have a most favourable effect on the annual balance sheet.

Rumours are rife as to which may be the next company to start working out agreements on similar lines with B.O.A.C. and the most frequently mentioned name in this context is Tasman Empire Airways.

Never a dull moment !

Walter Miller is a happy and efficient man who takes a pride in his job as a pilot with Slick Airways of U.S.A. But occasionally on long interstate freight hauls even Walter gets time to do a little reflective thinking and, like most men, he occasionally thinks about dames. How would it be to have a second co-pilot, young, blonde and curvacious — even his co-pilot, William Wohlschegel, might appreciate the feminine touch aboard.

But twenty minutes out from Detroit en route to Kansas, the flight engineer, Wallace Keck, was the first objective of the very friendly brunette who coyly tried to snuggle into his lap. It wasn't that Keck had anything against the opposite sex, but the company had pretty strict rules about this sort of thing, and after the initial surprise, this one was just a little too brunette.

Quickly sensing Keck's unfavourable reactions the lady withdrew and athletically, if with complete lack of dignity, climbed atop the radio racks, where she proceeded to give a demonstration of trapeze work which would have made even Burt Lancaster's hair stand on end.

Needless to say the rest of the trip to Kansas was a complete riot and the chimp, bound for a pet shop in Philadelphia, effectively resisted the combined efforts of the crew to replace her in the cage from which she had escaped. Not only did she give the crew a thorough shellacking but also polished off the entire supply of instant coffee and powdered cream.

The highlight was probably her occupation of the co-pilot's seat and her interest in taking charge of the flight. As Miller said later, with considerable feeling, " She was real friendly, but no help ! "

When the aircraft landed at Kansas the chimp was supervising operations enthroned on a radio rack. For a further twenty minutes she enjoyed what to her was obviously a delightful episode, and resisted the efforts of some six men, before being replaced in her cage.

The trouble women cause...

*

That particular night at Rome's Ciampino Airport had been up to then very much like any other night. Situation normal, everything under control, aircraft arriving and departing on schedule — a general picture of smooth-running activity.

This routine was rudely interrupted by the appearance of an emergency signal fired from the far side of the airfield, which, as would be expected, triggered off a whole series of reactions. Within seconds the alarm had been passed to aircrews, ground crews, fire services, police services and security services as the whole emergency forces of the airport swung into action. Even the local residents were aware that the routine had been broken as the sirens of police and fire cars screamed above the drone of the incoming aircraft.

Some little time later, when the excitement had died down and traffic had returned to normal, a worried airfield warden was still explaining with decreasing patience just what might have happened if a descending airliner had come face to face with two cows on the runway. As by this time the animals had returned whence they came, through a gap in the airfield fence, his story probably didn't sound very convincing, and our guess is he is still explaining...

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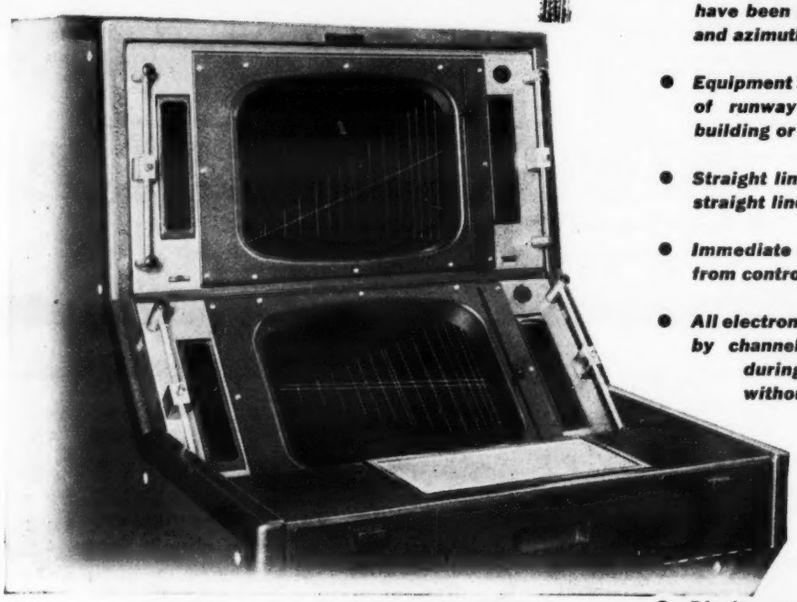
Precision Approach

RADAR



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- *Immediate visual checking of system from controller's position*
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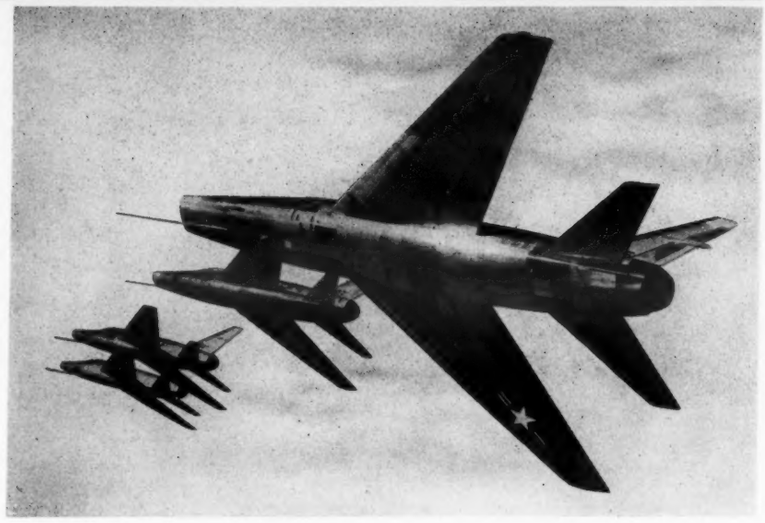

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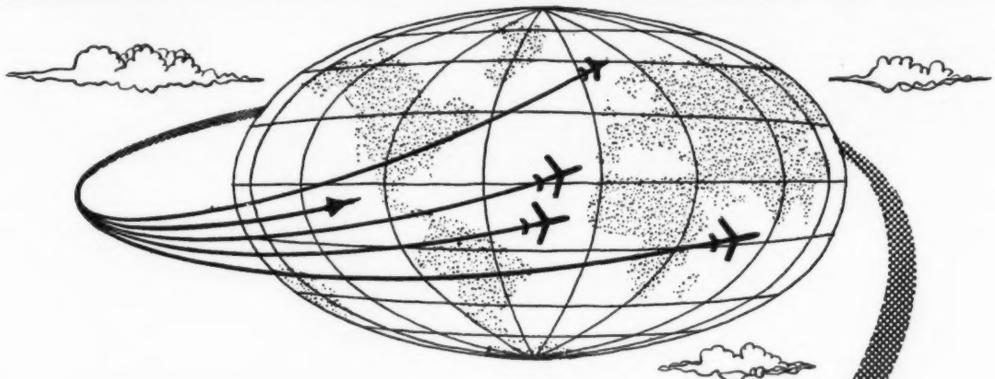

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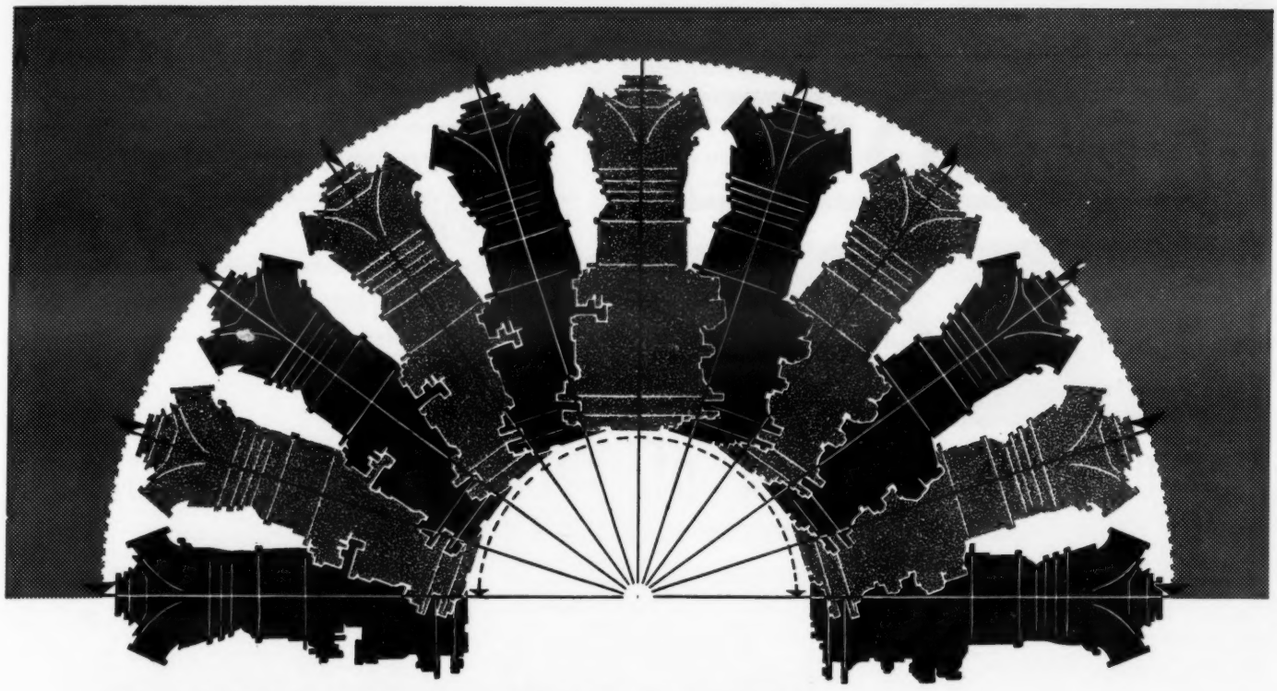
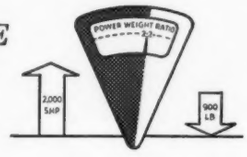


DESIGNERS WELCOME THE NAPIER GAZELLE

'Any angle' installation gives greater freedom

Napier's Gazelle offers a welcome break to 'tied' helicopter designers. This rugged free-turbine engine can be mounted on simple supports in the helicopter structure UPRIGHT, HORIZONTALLY, OR IN ANY POSITION IN BETWEEN.
This 'any angle' installation relieves the designer of many accepted limitations. It also gives him more opportunity to make proper use of fuselage space—valuable space which should, after all, be used for pay-load accommodation.



HIGH PERFORMANCE —LOW WEIGHT

The Gazelle has an impressive power/weight ratio. Originally designed for a power output of 1,260 s.h.p., it is now well on the way to developing 2,000 s.h.p. for a weight of 900 lbs.—a ratio of 0.45 lb./s.h.p. By removing the need for clutches, cooling fans, etc., the free turbine arrangement knocks pounds off the weight of the transmission mechanism.

30% RESERVE POWER

The design of the Gazelle provides a range of ideal helicopter powers. Among them are short-period emergency power outputs up to 30% above the normal maximum. Helicopters demand tough, reliable engines: the Gazelle is designed for strenuous duty and long service between overhauls. And when the time for overhaul comes, economical speedy maintenance is assured by the Gazelle's essential simplicity and the 'unit' principle on which it is built.

The Bristol 192—chosen by the British Royal Air Force —is powered by two Gazelles.

REPAIRS BY REPLACEMENT

This principle means that Gazelle components and assemblies are interchangeable—and easily accessible. Reduction gear, free turbine, compressor turbine and combustion system, compressor and accessories can all be replaced as self-contained, individually tested assemblies. The metering control unit can also be replaced as a rig-tested unit needing only minor adjustment.

The Gazelle is the most recent addition to the range of gas turbines made by D. Napier & Son Limited (London, W.3), who will be glad to supply further information.

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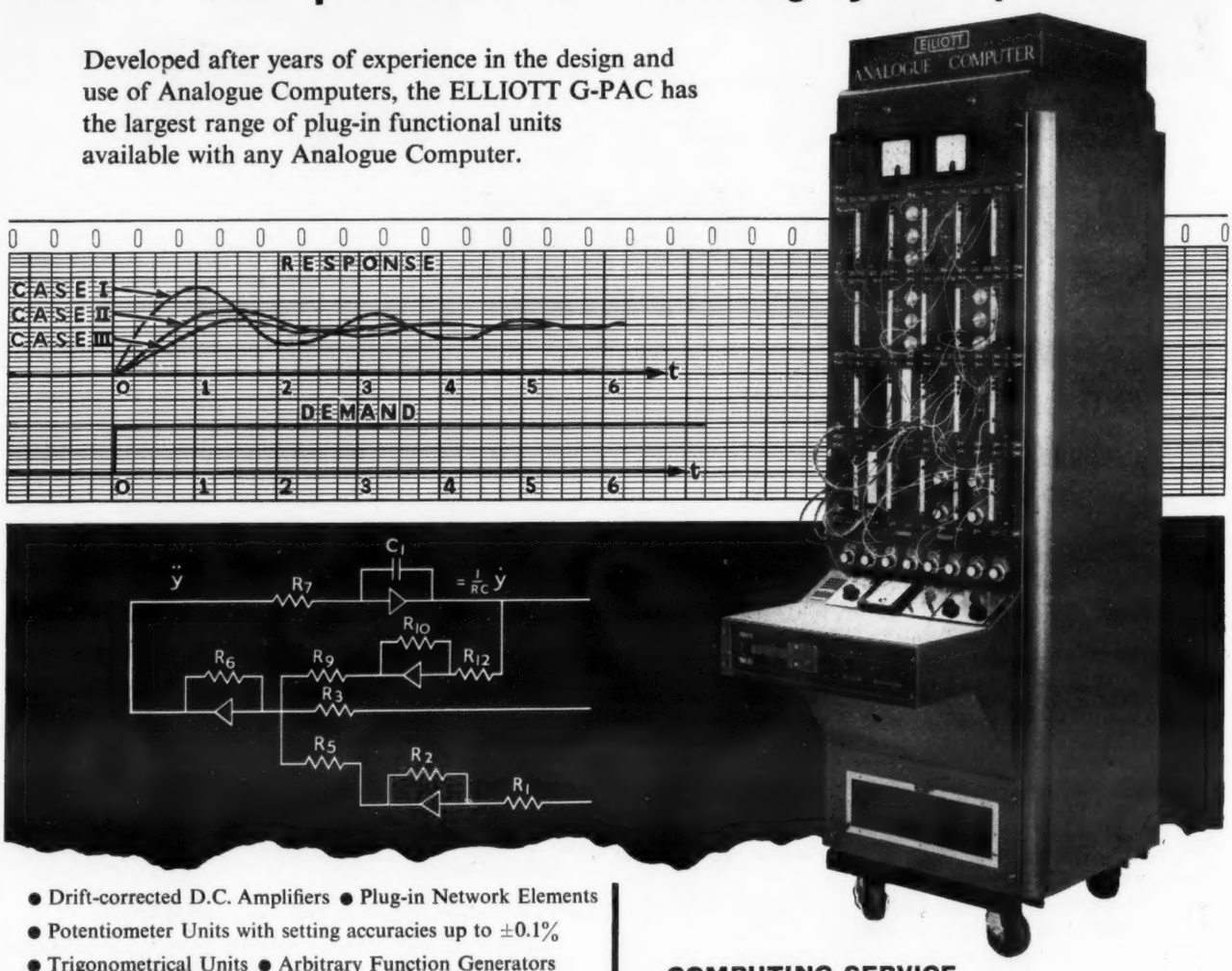

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These units, and others, can be used with a standard G-PAC, simply by plugging into the cabinet.

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Vertol tests world's first Tilt-Wing VTOL Research Aircraft

The new Vertol 76 is a true Vertical Take-Off and Landing (VTOL) aircraft, an experimental vehicle that casts a large shadow into the future.

With its ability to take off, hover and land like a helicopter it is independent of all but the most rudimentary landing area. Yet it flies from point to point with the dispatch of a turbo-prop passenger plane.

In this pioneer air vehicle the wing and rotor-propellers tilt as a unit through a 90° arc at the will of the pilot. For vertical flight he rotates the wing upward. To fly level he tilts the wing forward. Given a small runway, he can set the wing at the most effective angle to operate Model 76 as a Short Take-Off and Landing (STOL) aircraft and thus increase payload potential.

The Model 76, soon to undergo flight tests, has been developed by Vertol for the Army Transportation Corps and the Office of Naval Research as part of the military's ceaseless quest for greater mobility and efficiency. From flight tests will come experience and knowledge applicable to the bright future of VTOL in military and commercial aviation.

Since 1943 Vertol has been a pioneer in research and development of vertical lift aircraft. It is now the largest independent manufacturer of helicopters. You may find that our know-how, our experienced personnel, our test facilities and our productive capacity can help you solve a problem.

Engineers, if you are not already working for the government or defense industry, investigate job opportunities with Vertol.

VERTOL Aircraft Corporation

MORTON, PENNSYLVANIA

Revolutionary Simplicity in New **Skid Warning System** by **Goodyear**

Taps Pilot's Foot—he maintains full control over braking at all times

Now Goodyear has engineered a Skid Warning System* which (1) automatically senses an impending skid *before it occurs*, (2) *warns the pilot*, and, (3) for the first time in such systems, *allows the pilot to maintain full control and full "feel" of his corrective braking!*

The moment rotation of any wheel begins to drop at an abnormal rate, a tiny sensing device on the wheel hub actuates a small pulsating button mounted on the brake pedal. *This button literally "taps" the pilot's foot and tells him to "ease up" his brake pressure.*

As a result, the pilot keeps full command of his aircraft, he himself makes the corrective action—virtually eliminating the veering, flat-spotting of tires and wheel-locking formerly caused by inadvertent over-braking. Maximum safe braking is maintained and landing runs substantially decreased.

Standout feature of the new system is its simplicity. No brake modification is required. The Goodyear System can be installed easily on any type brake or brake system. FOR COMPLETE INFORMATION on this revolutionary development for greater landing safety, WRITE: Goodyear International Corporation, Aviation Products Dept., Akron 16, Ohio, U.S.A., or The Goodyear Tyre & Rubber Company (Great Britain) Ltd., Wolverhampton, England.

*Patents pending

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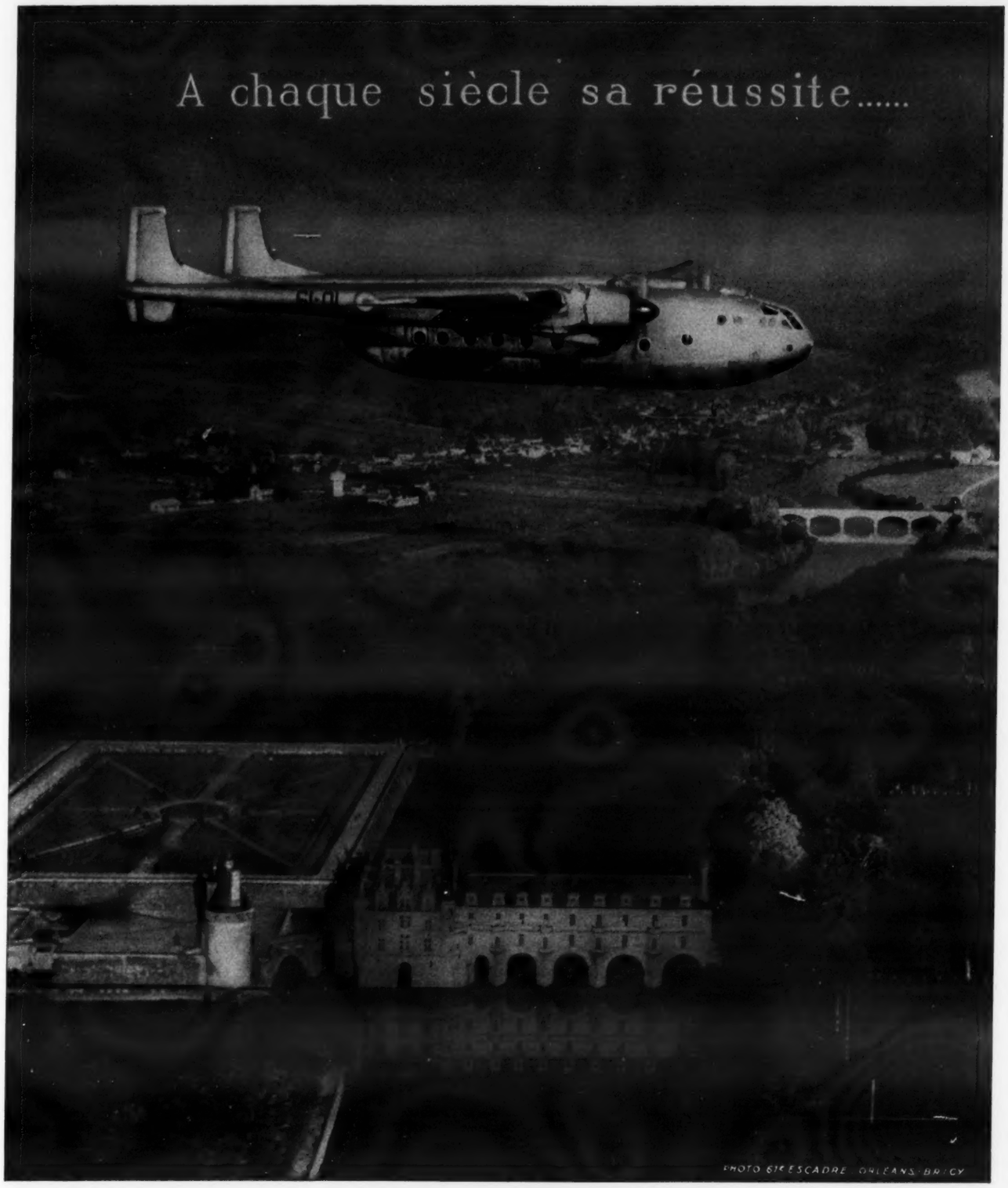
More aircraft land on Goodyear Tires, Wheels and Brakes than on any other make



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'...even in the cannon's mouth'

When a modern jet engine is running at or near full power, and particularly when it is travelling fast at a high altitude, any sudden change in the speed or pressure of the air that is flowing into its intake can so upset things that the engine will cut out completely.

What can produce a sudden change in speed or pressure? The blast wave caused by firing a cannon close to the air intake, for one thing.

This is a headache in which both engine designers and airframe makers have joint contributions to make. English Electric therefore carried out what were probably the first full-scale investigations into the nature and extent of such pressure changes around the air intake of a jet-engined aircraft. First we had to obtain apparatus that would respond to these exceedingly sharp, exceedingly short-lived pressure changes. Then we had to calibrate the apparatus. Then we installed it in a specially-built full-size nose section of the P.1, complete with its armament. Then we fired the guns and took readings.

In the light of these readings we made modifications which reduced the intensity of the pressure changes, and finally proved them by firing trials in the air at supersonic speeds.

This all took a long time and cost a lot of money, but it might have taken much longer and cost a lot more if we had just left the whole thing to chance.

Design starts from an attitude of mind

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Some Observations on Guided Missiles

By Theodore von Kármán

In preparing for the tests of the Azon-Razon glide bombs developed by the U.S. during World War II, one of the first precautions taken by the commanding officer of the Aberdeen Proving Ground was to double the size of the so-called danger zone of the testing range and to prohibit access there to all men and vehicles. I asked General (then Colonel) Leslie Simon what the reason for this measure was. "But think of it"—he answered—"these bombs are guided!"

The General's point of view was perfectly understandable, for, if a bomb is launched from an airplane unguided, it follows Newton's laws and its trajectory can be predicted with fair approximation. If, however, the bomb is "guided" who can be sure exactly where it will go and what it will hit?

Even after fifteen years of theoretical and experimental work in the guided missiles field, one of the main worries of designers and users is still the "reliability" of guidance and control systems. The situation is aggravated, of course, by the increasing complexity of modern weapons and by the growing number of components whose reliable performance and cooperation are needed to assure the success of a mission. It is easy to calculate that, provided each component has 98 % reliability, i.e. on the average misbehaves only twice in a hundred trials, the cooperative use of 35 components will reduce the resulting over-all reliability of the system to about 50 %, i.e. the missile will act correctly in only one half of the trials.

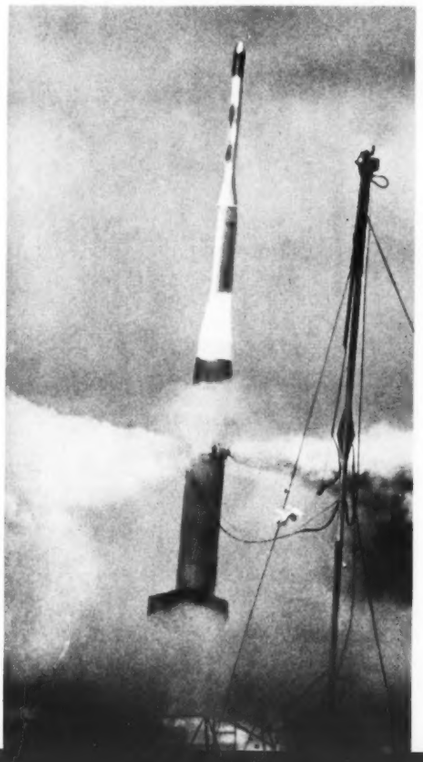
Guided missiles, of course, have various applications and use various systems for guidance and control. In general, these systems have evolved from a knowledge of the fundamentals of the art of guidance, especially by servomechanisms, which has developed during recent decades as a particular field of science comprising information theory and cybernetics. Relatively short range operations (either for aerial or underwater missions) can be accomplished by transmitting command information by tiny electric cables in order to actuate the control mechanisms. Radio or radar impulses can be used for either manual or automatic control. In the first case, an operator regulates the radar beam which the missile follows. In the second case, a programmed flight can be accomplished by tracking the missile with radar and transmitting to it the necessary corrections for maintaining the desired flight path. Homing devices may be constructed using radar either actively or by reflection of the radar waves from the target. Also, infrared techniques can be employed in homing applications, and for underwater devices, "sonar" homing may be used.

Radar control suffers from various diseases: e.g. interference, jamming and use of decoys by the adversary. Infrared has advantages as far as the jamming question is concerned but it is not so well protected against the diversion of heated decoys.

There is no doubt that inertial guidance, i.e. a process of integrating linear and angular accelerations of the missile to keep track of its position in space, is winning broader and broader applications. Because it is an integrating process, however, inertial guidance has the disadvantage of accumulating system errors. Nevertheless, great progress has been made in reducing the effect of possible errors by introducing automatic check procedures which use celestial or terrestrial objects of known location to correct for accumulated errors.

Missiles moving at subsonic and moderately supersonic speeds through the lower atmosphere may use aerodynamic control organs. This is especially true of missiles having wings, i.e. those depending on aerodynamic lift. Jet control can also be used with success at low altitude, as was done in the case of the Flying Atar exhibited at the recent Paris Air Show and in other VTOL devices. Once outside the atmosphere in the expanse of space, jet control is essentially the only method which is currently available.

According to Pentagon releases the blunt-nosed final stage of the 6 ton, 60 ft. tall Lockheed X-17 rocket research vehicle has reached the greatest speed recorded to date—i. e. 15,000 + m.p.h. The vehicle is being used to investigate heat problems arising on re-entry from the ionosphere to the atmosphere.



Numerous new fundamental problems were laid in the lap of the scientific community by the planning and development of so-called ballistic missiles, especially those for long range use, flying partially outside the atmosphere and at hypersonic speeds.

"Hypersonic" speed is defined as a regime where flight speed is large in comparison with the velocity of sound, and here the exactly opposite case is found to what is treated at low subsonic speeds where "classical" aerodynamics considers the medium incompressible, i.e. assumes that the velocity of sound is very large in comparison to all velocities in the flow field.

At first sight, the assumption of hypersonic flow appears as an essential simplification. For example, consider the impact of an ideal fluid on a sharp wedge. At low subsonic speeds, you may use a mathematical solution of the so-called potential flow theory. At higher subsonic flow, you have difficulties in establishing a proper solution for the equations of compressible fluids. As you arrive at supersonic speeds, you have a detached shock and a flow field which really cannot be exactly described analytically except by numerical integration. By increasing the Mach number still further, you arrive at the case of an attached shock. Now you are able to describe the flow field relatively easily, but the shock angle and the pressure exerted on the wedge are functions of both the Mach number and the wedge angle. When the Mach number reaches a value of about 5 or 6, the ratio between the shock angle and the wedge angle becomes independent of Mach number and is only slightly larger than unity. In this regime, the pressure acting on the surface of the wedge obeys Newton's classical law with good approximation; it is proportional to the square of the velocity and the square of the trigonometric sine of the angle of inclination. In fact, Newton's theory was based on the assumption that the air molecules hit the surface and are deflected to follow the surface. This is almost correct for the hypersonic flow, where the air is sharply deflected, although not exactly at the solid surface itself, but at the shock surface which follows it closely.

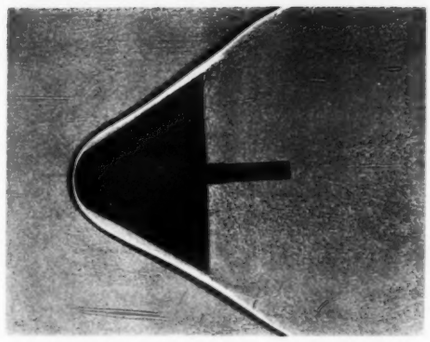
Unfortunately, when we are considering a real fluid like air and compute temperatures,

the picture changes fundamentally. First, we find that in the physical world no such thing exists as an infinitely sharp edge; the wedge always behaves as slightly "blunted". Thus, we have in fact a detached shock with large curvature, and this situation influences the development of the boundary layer and the flow field between the shock and boundary layers. Taking into account the fact that the air temperature at the surface of a moving body reaches the so-called recovery temperature which is only slightly below the stagnation temperature*, we arrive at the conclusion that the problem of flying through the atmosphere at speeds above Mach 2 or 3 becomes preeminently a problem of heat transfer and cooling and the feasibility of reentry of ballistic missiles becomes a first class headache above a Mach number of about 12.

The battle against the temperature barrier for manned and unmanned vehicles is essentially a question of technological development; the scientific foundation is well established. Of course, the problem of turbulent heat transfer and the laws of transition between laminar and turbulent state of the boundary layer are still under active consideration, but in general, scientists and engineers have the means of solution well under control.

The problem of reentry is more open to discussion, although nature shows us interesting examples from numerous meteorites which have reached the earth's surface. The main complications are:

* The ratio between the stagnation temperature and the ambient temperature for air is equal to one fifth of the square of the Mach number.



A shadowgraph picture of a blunt-nosed cone at a speed of Mach 8.3 in the hypersonic wind tunnel at Ames Aeronautical Laboratory (NACA). A very large amount of energy is contained in the heavy shock-wave extending back from the nose of the model; this energy represents heat kept from the model itself. H. Julien Allen, Chief of the High-Speed Research Division of the NACA Ames Aeronautical Laboratory has been decorated for his work in this field.

a) The temperatures behind the shock are so high that the air dissociates. Here we go out of the domain of aerothermodynamics and enter the field of aerothermochemistry. Dissociation and recombination have a substantial influence on heat transfer, since in the process of dissociation heat is absorbed, and in recombination, heat is again freed and has to be disposed of.

b) Heat transfer is so important that in the transient state of reentry, it is necessary for the "nose cone" not only to possess considerable capacity to aborb heat but probably has to be capable of shedding some of its material (by evaporation or otherwise) in order to survive the high temperatures it will encounter. As a result, one is faced with the somewhat unique situation involving aerodynamics of a body shape changing continually with time.

The fundamental discussion going on among scientists involved in these matters can perhaps be characterized as the battle between partisans of blunt and slender bodies. It is evident that bluntness or increased drag has the advantage that the critical transient state is shortened but can be exaggerated to the degree that the missile loses too much impact momentum. It is also evident that the partisans of slenderness have to watch out that their slender body does not disappear too early by melting.

When I meet people concerned over the phantom of intercontinental ballistic missiles carrying nuclear warheads and they criticize me for giving some thought to such terrible devices, I can readily point out a peaceful application of guided missiles. I believe the experience of a good breakfast is not complete without the companionship of a good newspaper. Thus, on my many flying trips between Europe and the United States I always ask the hostess for the morning paper. Of course she always replies sweetly: "Now how do you think we could possibly get the morning edition way up here over the Atlantic?" I can only shrug my shoulders, not daring to tell her that I seriously believe the "Times" or the "Tribune" should consider the development of a small homing rocket which could carry copies of morning newspapers to the airplanes shuttling between the shores of our great countries.

It all began at Agincourt!

Guided Missiles — AD 1415.

1 — Launching Ramp Mark I
2 — Firing mechanism
3 — Weapon guidance system
4 — Signals
5 — Ground control position
6 — Recording apparatus
7 — Logistics
8 — Bowser
9 — Fuelling point
10 — Booster rocket store
11 — Warheads
12 — Liaison Officer
13 — Area command
14 — War correspondents

Three Countries, Three Policies

By Colonel Jean Calmel, Paris

Colonel Jean Calmel, of the French Air Staff, formerly commanded the "Guyenne" heavy bomber squadron and took part, during World War II, in R.A.F. Bomber Command's day and night offensive. He is a Commander of the Legion of Honour and holds the Distinguished Flying Cross. — Editors

"New and more powerful weapons... are being delivered to our armed forces in increasing quantities... Furthermore, we are now engaged in the development of a whole new family of even more advanced weapons for all the services. Large expenditures will be required to bring these weapons into use. During the transition, we must continue to purchase enough of the current types to preserve our readiness until the effectiveness of the advanced weapons is demonstrated in tests..."

From President Eisenhower's Budget Message to Congress, January 1957

"Having regard to the high performance and potentialities of the Vulcan and Victor medium bombers and the likely progress of ballistic rockets and missile defence, the Government have decided not to go on with the development of a supersonic manned bomber... Work will proceed on the development of a ground-to-air missile defence system... the Government have come to the conclusion that the R.A.F. are unlikely to have a requirement for fighter aircraft of types more advanced than the supersonic P.1, and work on such projects will stop."

British White Paper on Defence, April 1957

"Though conventional means of defence can give us only relative and sometimes illusory security, the means of retaliation and reprisal are financially and technically within our reach... I have given the following instructions...

"That missiles be selected to succeed manned aircraft in the more distant future... It is not considered reasonable that interceptors and fighters be neglected entirely..."

Press conference held by French Defence Minister Bourgès-Maunoury, in May 1957

The progress already made in the field of guided missiles, the first of which are now in service, and the hope of producing weapons of virtually "absolute" efficiency raise, in a more acute form from day to day, the problem of their employment on an increasingly large scale and hence of the place they will sooner or later take in existing military systems.

The missile is designed primarily to replace the piloted fighter and bomber in the execution of the air defence and reprisals tasks essential in the atomic age.

This is undoubtedly one of the most serious problems now confronting the Great Powers' political and military leaders.

So much is at stake in the unceasing rivalry between East and West that false moves in the matter of missile planning must be avoided as far as humanly possible. But the cost of modern weapons and the necessity of continuing expensive research and development alongside current production, so as not to fall dangerously behind in technical progress, may dictate a choice between a number of alternatives.

In arriving at a policy decision, each country is bound to take into consideration not only the complexity of the technical factors involved, but also its own geopolitical situation, as well as its manpower, economic, industrial and financial resources.

The vast size of the American continent and the surrounding oceans require the United States to maintain a global-range bomber force, comprised of Boeing B-52 *Stratofortresses* (pictured) and B-47 *Stratojets*.

Until strategic guided weapons are available in production quantities, the U.S.A. continues with the development of piloted aircraft: the Convair B-58 *Hustler* supersonic combat aircraft.

Even inside the North Atlantic Treaty Organization, it is not surprising to find that the three major Western powers—the United States, Britain and France—should adopt substantially different policies.

The three individual policies are of course by no means as clearly defined as might appear from the extracts at the head of this article. They are frequently more complex. In other countries, the

The Bell *Rascal* (pictured) and the Martin *Bullpup* air-to-surface guided weapons are being utilized to extend the range of present day U.S.A.F. strategic bombers. Great Britain is also developing a "Stand-off Bomb" for use by the long-range V-class bombers.

The Northrop SM-62 *Snark* unpiloted long range strategic weapon will be a stand-in pending the availability of the "absolute" I.C.B.Ms *Atlas* and *Titan*. Range approx. 4,300 nautical miles. Self guided by inertial and automatic celestial navigation systems.

In order to ensure air defence in depth the U.S.A.F. has opted for long range all-weather fighter aircraft armed with air-to-air guided missiles. Left: a patrol of Convair F-102As taking off from George A.F.B., Calif. Right: the latest version of the Hughes GAR-1D *Falcon* air-to-air missile in front of an F-102A.

programme adopted will doubtless be amended before reaching its final format.

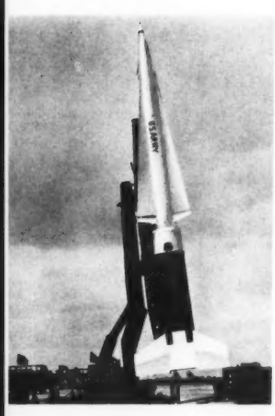
Nevertheless the quotations offer a reasonably adequate picture of the three countries' present activity in relation to the problems raised by the advent of missiles and their progressive substitution for combat aircraft, and hence in relation to the changes likely to result in the respective military policies of the United States, Britain and France.

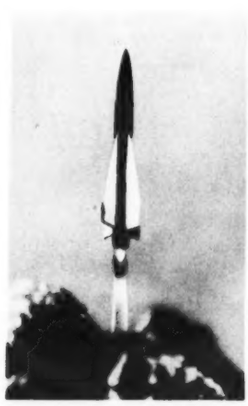
*

What actually is the problem? And when did it first arise? Unquestionably it was in 1944—45 that a country first set out to win a war with the aid of missiles. Hitler fought desperately, hoping until the end that his secret weapons would in time dramatically reverse the situation. If the V1s and V2s had carried atomic warheads, they probably would have achieved this.

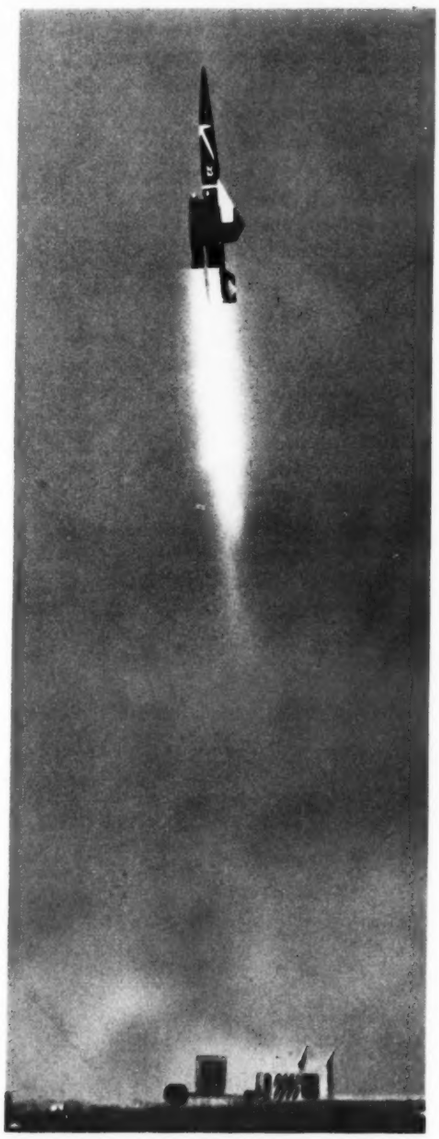
The German technical advances in the missile field at this time were extremely rapid, and Peenemünde was certainly the equal of any test centre today. But what could be done in wartime, when money and human lives counted for little, could not be continued at the same pace in peacetime. Hence progress has been much slower and developments less daring during the past twelve years.

Left: The new Douglas/Western Electric *Nike-Hercules* anti-aircraft rocket. Right: the Northrop/Raytheon *Hawk* sister weapon. Both weapons are being used by the U.S. Army.





The Boeing IM-99 *Bomarc* long range surface-to-air missile, itself armed with air-to-air rockets, seen at take-off with booster rocket burning. During the main flight power is supplied solely by two *Marquardt* ramjets, seen below the fuselage.



There are some who maintain, however, that projects are already reaching maturity. Like children itching to use a new toy, senior military authorities in some countries are trying to hasten developments; forgetting that in engineering there is no such thing as revolution but only evolution, they are demanding that projects be put into effect immediately.

Others, more cautious or perhaps merely wiser, foresee periods of transition and interim situations where piloted aircraft and missiles will exist side by side, with full utilization of missiles coming at a later date.

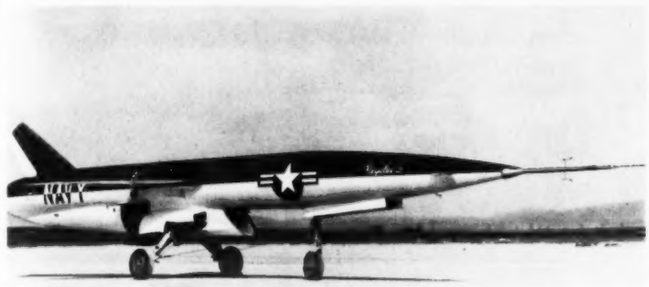
Who is right?

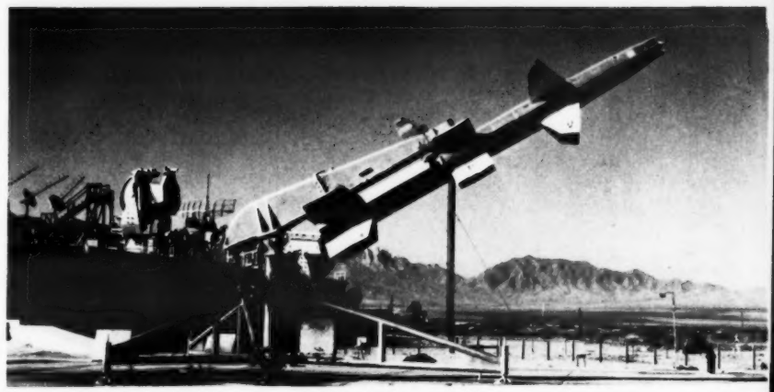
*

Before going to the root of the problem and analyzing the policies of the three Western powers—United States, Britain and France—it would be well to outline their attitudes to another question which, though not at first glance intimately connected with the main subject under discussion here, is yet symptomatic of their general approach and throws valuable light on their national points of view. This is the question of the distribution of missiles between the Army and the Air Force—allocation to the Navy is a matter of little or no controversy.

The problem of allocating *air-to-air* and *surface-to-surface* missiles has been relatively easily solved. The former are inevitably allocated to the Air Force, which is the only service in a position to use them. After some initial controversy, surface-to-surface missiles have also been allocated to the Air Force, with the exception of the short-range tactical missiles required for the actual battle-field, which are operated by the Army.

There has been no such clear-cut decision as regards *surface-to-air* missiles. The British have given them to the Air Force. In the United States, missiles with a horizontal range of less than 100 miles are the prerogative of the Army, while those with a range of more than 100 miles come under Air Force responsibility. Continental European countries such as Italy, Germany and the Netherlands have adopted the British attitude, while France has not yet made any decision as far as is known.





The U.S. Navy is developing its own offensive and defensive weapons. Left: the carrier-based Chance-Vought *Regulus II* guided jet bomber. Right: the Bendix/McDonnell *Talos*, ramjet with booster rocket, anti-aircraft weapon.

To cover overseas requirements the U.S. Forces have at their disposal a wide choice of medium and short range surface-to-surface guided missiles. From top to bottom: the U.S.A.F. Martin TM-61B *Matador* tactical bomber; the U.S. Army Martin *Lacrosse* surface-to-surface artillery rocket; the U.S. Army's Aerophysics Development / Grand Central Rocket / Utica-Bend *Dart* anti-tank rocket weapon.

Nevertheless the guiding principles for such a decision are accepted by all. The problem of establishing an airspace control system which would function with equal efficiency in both peacetime—with due regard for the requirements of air transport—and wartime, is one of the most difficult to solve. It is obvious that airspace control must be in the hands of a single authority if confusion is to be avoided, particularly during the approaching transition period in which piloted aircraft, whether civil or military, and missiles will be operated side by side. It is generally agreed that the authority responsible for airspace control should be the same organization as is responsible for air defence, or in other words the Air Force.

This argument is further strengthened when we consider the case of a surprise enemy attack. In such a case only the air defence organization, with its long-range surveillance, acquisition and tracking radar, is in a position to react sufficiently fast to alert the defence and reprisal forces.

Why then should there be such diversity in the application of so simple a basic doctrine?

Firstly, because in nearly all countries there are inter-service rivalries, and the partisan spirit sometimes carries the day, even among the more impartial leaders.

Secondly, and perhaps above all, because each country essentially bases its defence planning on its own particular needs. It therefore determines its programme in the light of its geographical situation and its financial resources. Although each of the three nations joined N.A.T.O. out of conviction and without ulterior motives, when it comes to defending its military estimates in Parliament, the Government concerned will be thinking primarily in terms of defending Washington, defending London, or defending Paris.

This natural egocentricity is one of the keys to the three powers' attitudes to the missile question. However, it is not the only explanation.

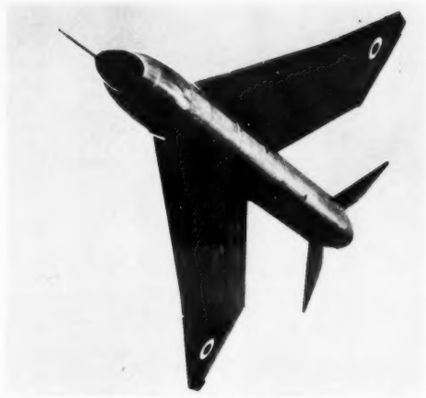
Take first the case of the United States

This country must be able to tackle a wide variety of tasks and consequently must possess an appropriate military system, within which the Air Force has been given a pre-eminent position not likely to be questioned again.

America's military policy is based essentially on the use of powerful nuclear reprisal forces and the provision of an efficient system of air defence.

Because of the very size of the North American Continent, bounded to East and West by great

The U.S. Navy's first guided missile cruiser, U.S.S. *Boston*.



Great Britain is presently basing her strategic plans on the use of the V-class bombers: Vickers *Valiant*, Avro *Vulcan*, Handley Page *Victor* (pictured). Right: The English Electric P.1 will be used for air defence of the British Isles.

oceans and to the North by vast icy wastes, and because of their determination to obtain the earliest possible warning of impending attack (which necessitates an air defence system widely deployed in depth) as well as to be capable of instant retaliation, the Americans must have aircraft capable of either attack or defence at long ranges from their bases on the Continent. These aircraft must then be supplemented at the earliest possible date by long-range anti-aircraft missiles and intercontinental surface-to-surface missiles.

But in addition the United States, being allied with the countries of Western Europe within the North Atlantic Treaty Organization, maintains forces in Europe and is thus obliged to construct a second system on a more modest scale, using interceptors and short and medium range surface-to-air missiles for local defence, with fighter-bombers and short and medium range surface-to-surface missiles for offensive tasks.

For any country other than the United States, with its vast economic and financial resources, such a dual programme would be out of the question. The American armoury of missiles covers every appropriate variety. These will gradually replace the piloted aircraft, in accordance with a carefully prepared plan. Nevertheless, piloted aircraft are still being developed and improved, without any apparent intention of discarding them as soon as possible in order to save a few millions or billions of dollars.

For example, the B-52 has gone into service, and its successor is already in existence, while at the same time work is being pursued on the "absolute weapon" represented by the *Atlas* or *Titan* I.C.B.M.s; similarly, such weapons as the I.R.B.M. *Thor* and *Polaris* are being developed for use, if required, in the interim period.

When they become operational, the *Bomarc* and *Talos* surface-to-air missiles will progressively replace the F-102, F-104, F-105 and F-107 fighters, all of which are already armed with *Falcon* air-to-air missiles and will later carry the *Sparrow III*.

The list of American missiles of various categories is a long one and is too well known to need repeating here. Above all it fully covers the wide variety of missions which the United States has undertaken in its ambitious and laudable desire to defend the free world.

*

Britain

is in a very different situation. She is highly vulnerable because of her island position, the density of her cities and her population crowded together in a relatively small area, and has limited financial resources. Hence, as soon as she judged it possible, a policy of economy was adopted, opting for the missile and sacrificing the aircraft. She has "skipped a step" by deciding to increase her nuclear arms at the expense of her conventional armament.

The British Government is thus taking full advantage of the privileged position of the British Isles within the air defence system for Western Europe on the one hand, and of the opportunites of exchanging technical information on missiles, and even of borrowing equipment, offered by its close relations with the American partners on the other. Finally, Britain has the undisputable advantage of possessing the atomic bomb.

The British therefore plan to construct a military system almost entirely based on progress in missiles. In this, Britain is consciously accepting a serious risk, which may even be described in some respects as a gamble (as Air Marshal Saundby admitted recently in a very interesting article in "The Aeroplane"), since it means that the country's security will be based on a very disputable theory, namely that missiles will be developed on a scale and at a rate that render superfluous any further effort in the field of piloted aircraft.

The British Isles cannot be defended in the vertical, as this would mean their destruction. On the contrary, the enemy's offensive forces must be "killed" on their bases. If these forces nevertheless succeed in taking off, they must be intercepted as far as possible from their targets.

The outcome of Britain's decision in the field of air armaments is well known: namely, maximum concentration on medium and long range offensive and defensive missiles, no light interceptors, no successors to the P.1 heavy supersonic interceptor or the strategic bombers of the "V" class.

However, the P.1s will be armed with air-to-air missiles (probably the *Firestreak*), and the bombers will carry long-range air-to-surface missiles with nuclear warheads, thus retaining their efficiency until the advent of the surface-to-surface ballistic missile.

The British gamble may perhaps be necessary for the economic health of the nation. It may succeed, at the cost of becoming to a certain

In the near future British air defence will be strengthened by the addition of the Bristol-Ferranti *Bloodhound* and English Electric *Thunderbird* surface-to-air weapons.

The Royal Navy has adopted the carrier-borne Armstrong Whitworth *Sea Slug* surface-to-air missile.

France believes that piloted aircraft will be indispensable for some time to come: A successor is already planned for the Sud-Aviation SO.4050 *Vautour* ground-attack aircraft (left), and all-weather fighter or bomber aircraft. In addition a series of supersonic interceptor fighters are under development: The Dassault *Mirage III* (pictured); Sud-Aviation *Durandal* and *Trident;* SNCA du Nord *Gerfaut* etc.

extent dependent on the United States for missiles. However, this dependence is counterbalanced by national production of nuclear warheads, which will preserve Britain's freedom of action.

*

France,

on the other hand, practically has her nose on the Iron Curtain. The shield seemingly provided by West Germany is completely inadequate at the dawn of the supersonic bomber era.

Her physical situation on the European Continent obliges her to make a special effort in favour of ground forces. Her role as a Great Power places her under the obligation to acquire the reprisal force which alone makes it possible to "dissuade" a potential enemy.

Finally, the defence and protection of overseas French territory may entail local wars of limited scope, where it is difficult to imagine the use of nuclear weapons and where, therefore, conventional weapons would have to be employed.

The funds which France can today allocate to her military budget are limited. As far as the Air Force is concerned, the funds available are even more restricted than in Britain, where

The Nord 5103 and Matra 510 were recently followed up by test flights of the Nord AA.10 rocket weapon (pictured).

roughly half the £ 650,000,000 spent on defence goes to the air arms (including the air share of the research and development budget).

Moreover, France also has to bear the burden of maintaining order in Algeria against a disintegration campaign which forms a real threat to N.A.T.O.'s southern flank.

The French Air Force thus has a complex task, but limited resources. The accent today is on the development of offensive forces, without however cutting down excessively on the air defence side.

France's aim is to establish an offensive intervention force as her contribution to the Atlantic Pact and to safeguard her overseas interests.

The object of the policy followed is to strike a suitable balance between the units equipped with piloted aircraft and those equipped with missiles.

France, therefore, has made no drastic choice, being convinced that piloted aircraft are needed now and in the future, because they are flexible in employment and cannot be jammed, and because of the time which must elapse before missiles can become operational.

Her current fighters, whose efficiency has already been increased by the introduction of air-to-air missiles, will therefore be succeeded by a new generation of light interceptors, tactical aircraft and all-weather fighters, all supersonic in speed and armed exclusively with missiles.

A supersonic bomber will also be coming along to succeed the *Vautour,* the fastest French light or heavy bomber now in service.

At the same time, with a view to defending the sensitive area represented by France, development of a long-range surface-to-air missile is continuing energetically. It is planned that this missile should be employed concurrently with the piloted aircraft, under a single control system.

Finally, surface-to-surface missiles with a range of 1,600 to 2,000 nautical miles are foreseeable, but in the more distant future.

Direction des Etudes et Fabrication d'Armement *Maruca* surface-to-air rocket weapon.

A Matra undesignated surface-to-air rocket weapon immediately after launching.

The Matra M.043 surface-to-air weapon has a SNCA du Nord ramjet with S.E.P.R. solid propellant rocket booster.

The Nord SS.11 wire controlled anti-tank weapon can be fired from jeeps and helicopters.

Remote control apparatus for the SNCA du Nord anti-tank weapon.

What is there to justify French hopes of materializing such a programme? Firstly her post-war success in the field of aircraft manufacture. *

French successes in the missile field are equally striking. The reason is perhaps that in this field progress is determined less by cash than by intellectual capacities.

Examples of air-to-air missiles are the Nord 5103, which is now in production, and the Matra 511, still on the secret list. Among surface-to-surface missiles the Matra 422, Sud-Est 4400 and Dassault S.A.100 show great promise. Finally, with surface-to-surface missiles such as the Sud-Est 4500 and the *Jericho*, France hopes to cover all the tasks she has elected for herself.

The earlier Nord SS.10 has slightly swept cruciform wings.

Thus, a country's overall military policy, the choice it will make among existing or future categories of weapons and its attitude towards missiles are today inspired largely by its own particular requirements, which are in turn dictated by its overall situation. It is thus interesting to note that the attitude of the various Continental Western Europe countries is roughly similar.

France, Italy, the Netherlands, West Germany and Belgium are faced with the same problems within the same geographical framework, and hence have the same operational needs. These countries must therefore aim at joint planning and the joint production of standard equipment. In the field of ideas, and even of practical realizations, the various national outlooks not only approach but also supplement each other. The proof is the number of contacts, both civil and military, established between manufacturers or military chiefs, who are all anxious to cooperate in order to produce standard equipment to meet common requirements.

It is natural that France should wish to see a healthy development of this essential industrial cooperation, which should be animated solely by a desire to serve the common good of the European community, with full respect for the independence of all partners, without seeking individual commercial advantages or jockeying for positions of superiority.

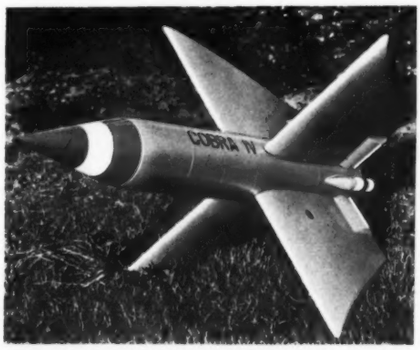
The perhaps ambitious tasks which France has set herself today in the matter of air policy might well be lightened by effective cooperation of this kind. Even if this should be the prerequisite for their success, it would be unfair not to recognize that such success would be shared with the whole European community.

The French aircraft industry may perhaps not reach its full stature until a United Europe is in being, when the patient and stubborn efforts which the French have put into building up this industry will be recognized as having been a contribution to the welfare of all member countries.

The smaller powers' guided weapons

Switzerland, Sweden and Italy are employing the Oerlikon 54 and 56 anti-aircraft rockets. Japan has recently acquired the licence to manufacture.

The Contraves-Oerlikon-Bölkow *Cobra 4* wire controlled anti-tank weapon.



* The *Trident* and the *Mirage III*, for example, are undoubtedly the best aircraft in their category anywhere in the world today, and their production in quantity would be within Europe's means. Also, the *Atar Volant* and later the coleopters will perhaps provide a solution to the crucial problem faced by Germany and the other countries along the Iron Curtain which have no depth for their air defences.

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The Rocket Comes of Age

By Dr. Wernher von Braun, Chief, Guided Missile Development Division, Redstone Arsenal, Huntsville, Alabama

Dr. Wernher von Braun, an American of German birth (born at Wirsitz, near Bromberg), first became interested in rocket development at the age of ten and spent so much time on his hobby that his school studies seriously suffered. Reinickendorf, Kummersdorf... there was no German rocket test base where von Braun was not at home. Appointed to the German Army's Peenemünde establishment by Dr. Walter Dornberger, he assisted in the design and construction of all German missiles up to the end of the war, then moved to the United States, acquired American citizenship and was finally appointed Director of the U.S. Army's Guided Missile Division at Redstone Arsenal, Huntsville, Alabama. His ultimate goal is the practical realization of space travel. — Editors

The development of rocketry is proceeding at such an accelerated pace, spurred by the military need, that it is quite difficult at this point in time to establish any physical limits upon the future of guided missiles.

The one aspect which has fired the public imagination is that of the exploration of outer space by man. Until very recently the relatively small group of scientists and technicians who seriously discussed this adventure were assumed to be visionaries, dreamers, or even worse. Successive technological break-throughs have furnished concrete evidence of the validity of their theories and they have now attained the aura of respectability.

The child avidly watching an articulate image upon a television screen would assure you that man has been roaming about in outer space for months and years. The 20th Century heroes of comic pages, radio and motion pictures, waging the good fight against villainous planetary marauders, are entirely believable to the young of this generation.

Their parents, too, must conclude that some human is about to set foot on the Moon as they read eye-catching advertisements of missile builders which are keyed to space exploits, and news of the expenditure of billions of dollars for long-range ballistic missiles.

The mass of rocket literature has world-wide impact and origin. Not long ago a publication in the Soviet Union forecast journeys in rocket vehicles between New York and Moscow. Sports writers use terms familiar to rocketeers in describing major league baseball games. We suffer more from a surplus of high-pressured salesmen than from a dearth of scientific talent.

However, the sober facts known to the public are sufficient to warrant a conclusion that the rocket has come of age. It may be in a relatively immature stage and it may be some time before it reaches full maturity, but this is the natural and logical sequence of any revolutionary, technical advance.

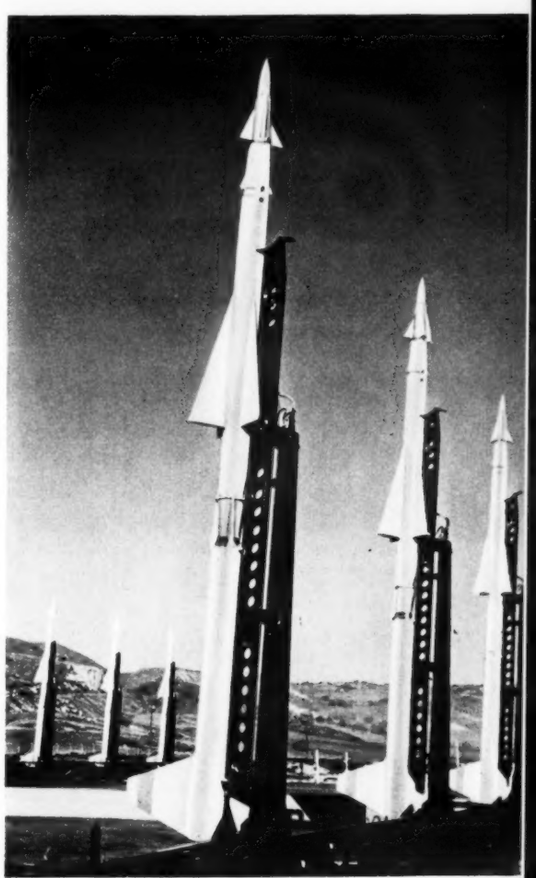
Some consternation has been expressed by air power advocates over the premature acceptance of the long-range ballistic missile as the "ultimate" weapon. They argue that it will be many years, if ever, before the airplane gives way to its robot successor. It should be realized that the long-range missile as a military tool for strategic bombardment is not the only threat to manned aircraft.

Major General J. B. Medaris, who leads the U.S. Army's ballistic missile program, warns that "the airplane bids fair to have the shortest total life of any effective delivery system". He speaks, of course, of the airplane as a weapon, as an instrument to strike at either ground forces, other aircraft, or strategic targets.

Surface-to-air fire by artillery and rockets took a heavy toll of aircraft in World War II. The percentage of losses to ground fire in Korea ran even higher. With the advent of still more deadly anti-aircraft rockets of increased range, greater accuracy and maximum lethality, it is reasonable to conclude that the rate of kill would surpass anything heretofore experienced. Thus it becomes urgently necessary, for the adequate defense of our country, to develop other delivery systems which can take over the airplane's mission as a weapon and provide us with a retaliatory capability so awful that no aggressor would dare launch total war.

In this aspect, the growing influence of the missile has already been felt. Some reduction in tactical air wings is contemplated. The Army is simultaneously moving to organize new Artillery missile groups which will employ these weapons in the field.

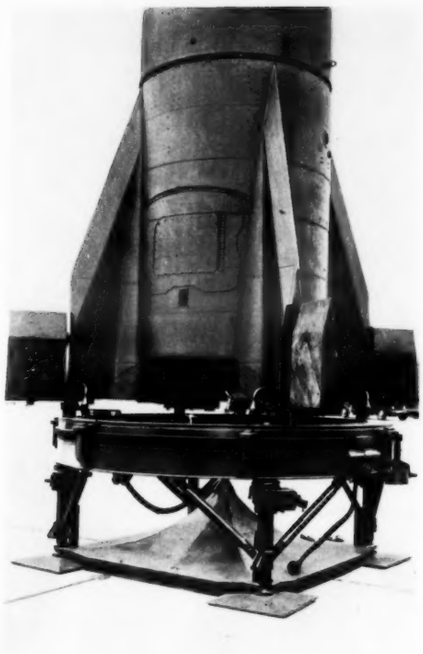
Such fundamental changes in tactics and strategy leave no room for doubt that the rocket is here and now. To illustrate the point, the Army has deployed the *Corporal* ballistic missile with atomic capability with its forces in Europe. The *Honest John*, a large caliber free rocket, has been



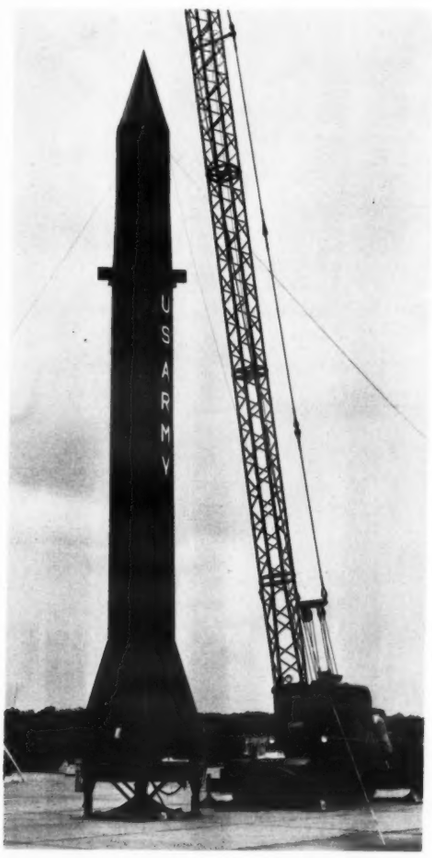
Part of a U.S. Army *Nike-Ajax* battery at the ready "somewhere in the United States". The anti-aircraft rocket, a joint development by Douglas and Western Electric, is launched from vertical rigs with the aid of a powerful solid-propellant booster. Its main propulsion unit is an Aerojet-General liquid-propellant rocket motor.

A Martin *Lacrosse* solid-propellant artillery missile (at the U.S. Army Ordnance Guided Missile School), flanked by a Firestone *Corporal* short-range missile (left) and a Douglas/Emerson *Honest John* unguided rocket (right), during a public demonstration at Huntsville, Alabama.

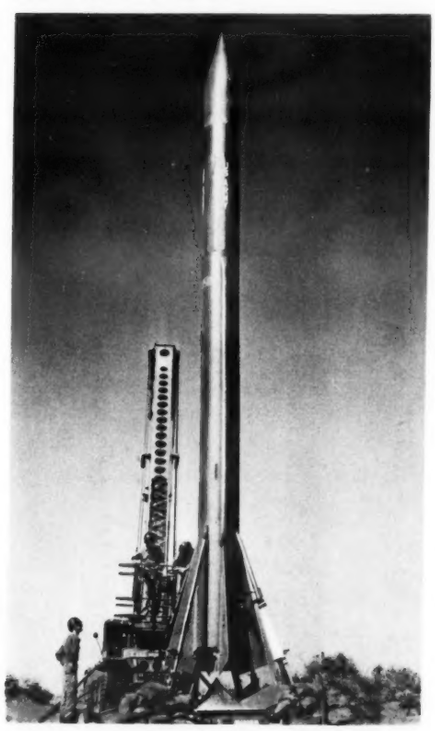
The larger, more advanced *Nike-Hercules*, with sharply swept, cruciform delta wings and large aerodynamic control surfaces.



The *Redstone* medium-range missile (for a radius of 250 nautical miles) was developed at the U.S. Army's Redstone Arsenal, Huntsville, Alabama, under the supervision of Dr. W. von Braun. It is equipped with a liquid-propellant rocket motor, jet flaps and aerodynamic control surfaces. Pictures show the weapon on its launching platform (bottom left) and during climb (top left). Top right, details of the launching platform complete with rocket.



Below, the U.S. Army's Firestone *Corporal* short-range missile (for a radius of up to 50 nautical miles) being tested at White Sands Proving Ground, New Mexico. The liquid-propellant rocket motor for this weapon was built by the Jet Propulsion Laboratory, and the beam guidance system by Gilfillan.



in the hands of troops for several years. *Nike Ajax* is the Army's anti-aircraft weapon in being, protecting our cities, and is being succeeded by an advanced version, *Nike-Hercules*.

The Army is preparing to deploy the *Dart*, a small guided missile primarily designed to destroy tanks; the *Lacrosse*, a new surface-to-surface guided missile for close support on the battlefield; and the *Little John*, a small-caliber field artillery rocket.

Soon the Army's newest and largest weapon, the *Redstone* Ballistic Missile, now in production, will join the arsenal of rocket firepower. It is capable of all-weather atomic fire support and will greatly extend artillery range.

One of our great popular magazines, "The Saturday Evening Post", stated that the launching of the first V-2 rocket September 8th, 1944 was the "starting point of the ballistic missile age". As one close to the story, I can testify that the advances since then, particularly in the last two years, have been so enormous that it would be foolhardy to underrate the importance of the ballistic missile—either as a weapon or in its broader meaning, as a superb delivery system for whatever resources man requires.

Even now the U.S. Army has disclosed that work has begun on the anti-missile missile, indicating that our military planners are determined to keep abreast of progress in the development of firepower. It is true, of course, that the Intermediate Range Ballistic Missile and the Intercontinental Ballistic Missile are not yet operational and are still experiencing the pangs of growth. Estimates of when the *IRBM* can be fielded vary. In any case, they cannot be disclosed for obvious reasons.

The free world must assume that a potential enemy has achieved comparable progress in the development and application of rocket-powered weapons systems. To assume otherwise would be to risk massive destruction by systems comparable to those which we are now heavily engaged in perfecting.

Out of this military effort are emerging superior propulsive and guidance systems which will ultimately permit manned orbital flight and the building of manned satellite stations.

Such space platforms orbiting around the earth would provide unequalled vantage points for observation, either to disclose instantly any offensive preparations at any point on the globe, to pursue our study and increase our knowledge of outer space and the planetary system, or for the purpose of forecasting weather. It has been estimated the potential savings involved in the latter use alone would run into billions of dollars annually. The use of space platforms as television and communication relay stations will offer further great commercial opportunities. There can be little doubt that orbital platforms can be made to pay their own way.

Once we have fully exploited the capabilities of the manned satellite, we shall be ready to undertake our greatest adventure, the exploration of our neighboring worlds. Having passed the midway point in the 20th Century, we suddenly seem much closer to the Moon.

Looking Forward

By Mundy I. Peale, President,

Republic Aviation Corporation, Farmingdale, Long Island, New York

Now that the age of jet-nuclear air power is well advanced and a good start has been made in guided missiles, it seems to me that a misconception is forming in the public mind as to where we stand in missile development. I feel we should clarify this situation as soon as possible because it is dangerous for the public to draw incorrect or premature conclusions from the headlines that naturally attend almost every step in the development of missiles and rockets.

The age of missiles, although dawning, is not yet a reality. Because of the very necessary security regulations, specific progress reports on the state of the art in the many sciences contributing to missile development cannot be expected. There is, however, sufficient evidence to make it apparent that more than a few years will be required before guided missiles will become the dominant factor in military strategic and tactical operations. A significant fact is that it will be at least five years before missiles are allocated even half the procurement dollars of the United States Air Force. Some of these dollars will be for missiles to be fired from airplanes, both at surface targets and at enemy aircraft.

A recent survey in the United States of men ranking high in the nation's missile program reflected the general belief that the 1,500-mile intermediate range ballistic missile—the I.R.B.M.—is two to four years from true operational status and the 5,000-mile intercontinental ballistic missile—I.C.B.M.—is several years further away. Planned delivery dates of missiles to combat units have not been revealed, for obvious reasons.

This compilation of views of an impressive list of men closest to developments in the missile field is the kind of evidence that thoughtful men heed. Unfortunately, however, such news as the announcement by Britain's Defence Minister Duncan Sandys that the United Kingdom is abandoning its aircraft development program is the sort of thing that makes the bigger headlines. Too few people take pains to read beyond the headlines to understand that Britain's drastic decision was dictated by her limited defense funds rather than the belief that the missiles era had, indeed, arrived.

Major General Bernard A. Schriever, who directs the U.S.A.F.'s long-range missiles program, said this winter that we still are far from the pushbutton type of warfare. "The guided missile still is in its infancy and subject to many growing pains."

The scientist in charge of the technical direction of the program, Dr. Dean E. Wooldridge, recently stated: "In the next ten to fifteen years, we will find guided missile weapons systems will come to be important in our arsenal of weapons but will not be available even in limited numbers to perform many Air Force functions. Much more than ten to fifteen years will elapse before manned aircraft will become as unusual in our air power as guided missiles are now."

Even when developed and operational, the missile and manned aircraft will be used in conjunction, and for a very long time. It is questionable that the day will ever come when our air forces will do everything with missiles. Manned vehicles, whose capabilities and usefulness will grow along with missiles developments because much of the knowledge and advances deriving from the missiles will be simultaneously applied to manned craft, will always have the advantage of carrying out reconnaissance and selecting the target en route.

Meanwhile, however, research in missilery is moving at a pace unprecedented in scientific history. It encompasses a lavish outlay of money, and the efforts of the greatest number of scientists, engineers and technicians ever to concentrate on a single field of endeavor.

Each successful advance spurs men's imaginations and brings us a step closer to the day when we may hope to see the many mysteries of the upper atmosphere and beyond explored and even navigated. Aviation medicine is hard at work exploring the problems of man's survival, first in circumplanetary—or orbital—space flight, and then in interplanetary space flight. This is no longer the dream-stuff of science fictionists, but the practical work of sober, practical men of high skill and training. They are probing the state of weightlessness, where the force of gravity no longer has meaning, and its effects upon the general well-being of humans. (Where, to over-simplify the problem, you cannot drink a glass of water in the ordinary way, because water will not flow downward.)

In the field of peaceful uses of missilery, hard-to-imagine advantages of transporting goods and people beckon to the scientific, commercial and financial world, and we are entering an area in which not even the sky is the limit.

First official picture of Convair's Sycamore Canyon test centre (near San Diego, California) for the *Atlas* I.C.B.M. Test launchings of *Atlas* rockets, however, have so far been made at the Air Force Missile Test Center, Patrick, Florida.

Missiles at the Paris Show

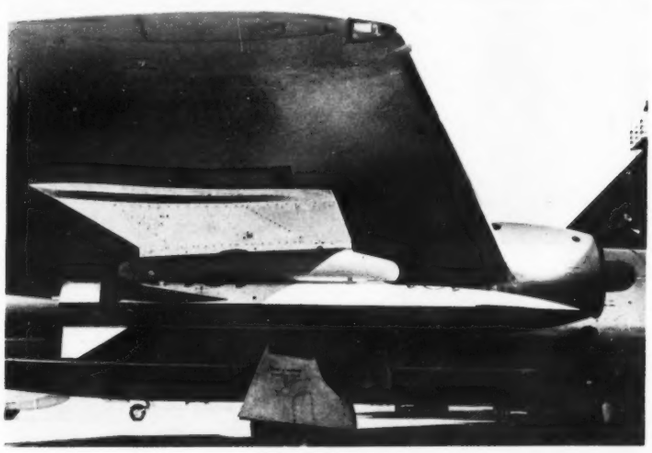
A Military Assessment

By Michel M. Decker,
Ingénieur Militaire en Chef de l'Air, Paris

Fairey *Fireflash* air-to-air missile on its ground service trolley.

Nord 5103 air-to-air missile.

Matra 510 air-to-air missile.



One of the most striking features of the 22nd Paris Air Show was undoubtedly the varied range of guided missiles exhibited. More than ten operational missiles were shown, most of them never seen in public before, thus underlining a number of "hard facts" which should perhaps be considered before proceeding further.

Firstly there is the fact that this particular variety of "flying machine", regardless of the roles for which it is envisaged, has been developed and produced solely by the aircraft industry. Secondly there is the important part which such weapons play in both Britain's and France's defence planning. The value attached to missiles is evidenced not only by Government statements in recent months (such as the White Paper on Defence and Monsieur Bourgès-Maunoury's exposition on France's arms policy over the next ten years), but also, even more clearly, by the progress made in actual production. Finally, the technical level attained and the fact that several projects have reached the operational stage reveal in some cases that advances have been greater than had hitherto been thought.

In addition to British and French manufacturers, the U.S. Air Force, whose efforts in the guided missile field have received greater attention, also showed two of its offensive bomber missiles. Here it differed from the European exhibitors, who demonstrated primarily defensive weapons.

*

The following is a list of the missiles seen at Le Bourget.*

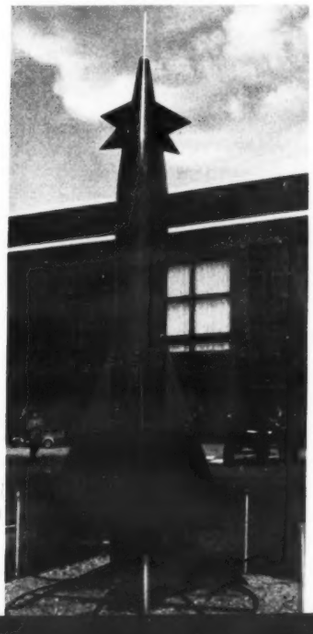
• Three air-to-air-missiles

1 — Fireflash (The Fairey Aviation Company, Ltd.): Missile with straight cruciform wings and tail surfaces, powered by two staggered solid-propellant rockets externally mounted. The warhead has a proximity fuse and is thus detonated at the point of shortest missile-target range: length approx. 9 ft. 7 ins.; span 2 ft. 3 ins.; calibre of central body 5 ins.; burnout Mach number approx. 2; range, not disclosed; suitable for high and medium altitudes; two solid-propellant rockets of 1,100 lbs. thrust each; beam guidance from the parent aircraft with special countermeasures against enemy jamming.

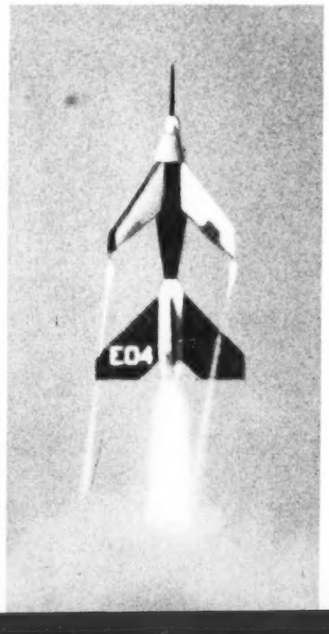
2 — Nord 5103 (S.N.C.A. du Nord): Guided missile with sharply swept cruciform wings: length approx. 8 ft.; span approx. 3 ft. 4 ins.; calibre 10 ins.; weight approx. 300 lbs.; burnout Mach number 1.7 (for launching at Mach 0.9); two-stage solid-propellant rocket motor; unspecified radio guidance system.

* Cf. the illustrated report "Open Market for Guided Missiles" in *Interavia* No. 7, 1957, p. 697 etc.

Parca surface-to-air missile.



SE. 4300 surface-to-air missile.



The wire-controlled Nord SS.10 (Arsenal 5203) "tankbuster" can be fired direct from its transport container if required; otherwise it is launched from a jeep or helicopter: range 200 to 1,700 yards.

A Sud-Aviation SE.4200 ramjet-powered surface-to-surface missile in flight: the warhead is suspended beneath the fuselage; launching with two boosters from a truck platform; range 55 nautical miles.

3 — Matra 510 (Société Générale de Mécanique — Aviation — Traction): Guided missile of "canard" design, with delta wing (at rear) of pronounced dihedral, elevator unit attached to missile nose, rudder unit at rear: length approx. 9 ft. 10 ins.; span approx. 3 ft. 4 ins.; weight 350 lbs.; burnout Mach number 1.7; two-stage solid-propellant rocket motor; optical homing head.

• Three surface-to-air missiles

4 — SE.4300 (Sud-Aviation): Practice missile for personnel training and testing radio guidance systems; with sharply swept cruciform wings; length approx. 18 ft.; span approx. 7 ft. 1 in.; weight approx. 2,200 lbs.; burnout Mach number 0.9; liquid-propellant rocket motor with variable thrust; vertical launching with booster.

5 — PARCA = Projectile Autopropulsé Radioguidé Contre Avions (Direction des Etudes et Fabrication d'Armement): Guided missile with cruciform delta wings of wedge-shaped airfoil and cruciform guide vanes at the nose; length approx. 16 ft.; span approx. 7 ft. 1 in.; weight approx. 2,200 lbs.; burnout Mach number 1 +; combat ceiling approx. 65,600 ft.; rocket propulsion unit and up to four boosters (with guide vanes); launched at any desired angle from an adjustable mobile ramp; radio guided from the ground.

6 — Thunderbird (The English Electric Group of Companies): The model of this missile exhibited had straight cruciform wings and guide vanes, both of trapezoidal planform; other components—from front to rear—are: electronic group; stabilizers and accelerometers; container for inert gas; propellant tank; servo motors for control surfaces; combustion chamber; length approx. 20 ft.; span approx. 4 ft.; calibre 42 ins.; burnout Mach number 2. Napier liquid-propellant rocket motor (concentrated hydrogen peroxide and kerosene) of approx. 2,200 lbs. thrust; launched from an adjustable mobile ramp (at any desired angle) with the aid of four solid-propellant boosters with guide vanes; self-contained ground organization; guidance system developed by Marconi's.

• Four surface-to-surface missiles

7 — Arsenal 5203 or *SS.10* (S.N.C.A. du Nord): wire-controlled short-range missile for ground operations, in particular for anti-tank use (for which purpose a hollow charge is provided); slightly swept trapezoidal wings (cruciform) with spoilers on the trailing edge, without separate guide vanes; length approx. 2 ft. 10 ins.; span 2 ft. 6 ins.; calibre 6.3 ins.; weight 33 lbs.; range from 200 to 1,700 yards; average speed 260 ft./sec.; mean kill probability 80 %; solid-propellant rocket motor; launching from short ramp, or even straight from the transport container; command guidance (commands transmitted via two wires unwound from a drum), using a three-point target-coverage system.

8 — SE.4200 (Sud-Aviation): Aircraft-type missile with slightly swept mid-set wings and fins at the wing tips, without tail unit; military loads are attached beneath the fuselage; length approx. 10 ft.; span approx. 7 ft. 1 in.; weight 660 lbs.; Mach number approx. 0.9; range 55 to 60 nautical miles; high accuracy; powered by a ramjet and two take-off rockets; launched from a carriage mounted on a truck; radio guidance.

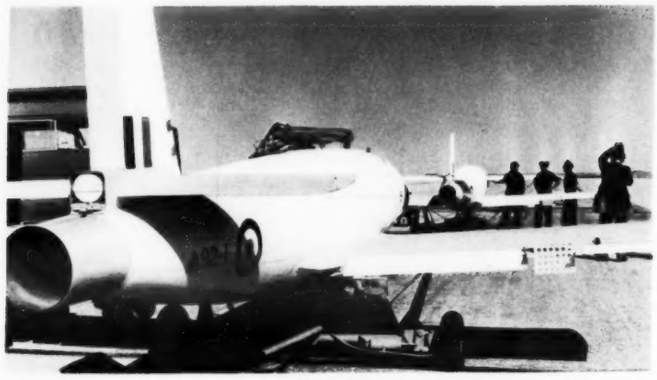
9 — TM-61C Matador (The Martin Company): Pilotless tactical/strategic guided bomber with Allison J33 turbojet of 4,840 lbs. thrust and take-off rocket of 29,700 lbs. thrust. Sharply swept high-set wings and conventional high-set tail unit. Structure built largely of bonded magnesium alloys, wings of sandwich construction with honeycomb core; air intake beneath the fuselage; length 39 ft. 8 ins.; span approx. 29 ft.; calibre 55 ins.; gross weight approx. 12,000 lbs; launched from a 40-ft., 16-ton special rig; radio guidance. (Designed in 1946; first flight 1949; operational since 1952.)

10 — SM-62 Snark (Northrop Aircraft Inc.): Pilotless self-guided strategic missile with Pratt & Whitney J57 jet of approx. 11,000 lbs. thrust, plus two boosters of 33,000 lbs. thrust each. Sharply swept mid-set wing with "saw-tooth" leading edge and auxiliary fuel tanks beneath the wings; elevator unit attached to wing, rudder unit at fuselage rear; length approx. 70 ft.; span approx. 42 ft.; gross weight approx.35,000 lbs.; launching ramp mounted on a trailer (transportable by air).—The *Snark* flies at high altitude at the speed of a modern jet fighter and dives on its target at supersonic speed; its maximum range is roughly 4,300 nautical miles; it is equipped with a gyro-stabilized system for automatic astronomic navigation (and with inertial navigation instruments).

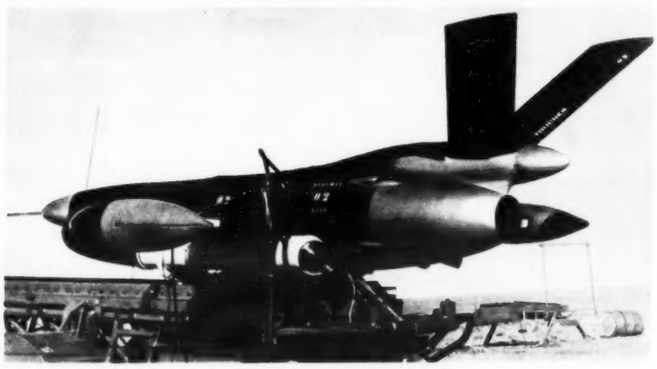
The above list must be supplemented by two British guided missiles, which were represented only "symbolically" in Paris.

Martin TM-61C *Matador* tactical/strategic guided bomber for the U.S. Air Force: radio guidance.

Northrop SM-62 *Snark* strategic self-guided bomber (U.S. Air Force): inertial navigation and automatic astronomic navigation.



Jindivik remote-controlled target aircraft, built by the Australian Government Aircraft Factory (on take-off trolley).



S.N.C.A. du Nord's CT.20 remote-controlled target aircraft (on launching carriage).

11 — Firestreak (de Havilland Propellers Ltd.), an air-to-air rocket with infra-red homing head.

12 — Bloodhound (The Bristol Aeroplane Company, Ltd. and Ferranti, Ltd.), surface-to-air missile with semi-active homing head.

*

In addition to the pure combat missiles, a number of *remote-controlled target aircraft* were shown, namely the French CT 20 (Nord 5510) and two ECA (Etudes et Constructions Aéronautiques) drones, as well as the Australian *Jindivik* (demonstrated by Fairey). *Research rockets* included a number of O.N.E.R.A. mockups and one of Curtiss-Wright's Hypersonic Test Vehicles. Finally, there was a wide range of missile components of all kinds, such as ramjet engines (Bristol *Thor*, Curtiss-Wright ramjet, S.N.C.A. du Nord ST.450) or solid-propellant rockets (SEPR), fibreglass cases for missiles (Bristol), and accessories such as guidance equipment and instruments.

What conclusions can the military observer draw from this impressive collection?

It is generally agreed that the more modest an interceptor's performance, the greater is the need for air-to-air rocket weapons. Air-to-air rockets are therefore typical armament for light fighters, although they also play an important part in the all-weather fighter's arsenal. They therefore offer an ideal means of giving the piloted fighter a new lease of life, and were shown in Paris on board several fighter types, such as the Sud-Aviation *Durandal* (a Matra 510), the Sud-Aviation *Aquilon* carrier-based fighter (two Nord 5103s), the *Vautour* multi-purpose combat aircraft (four Nord 5103s). It is also known that the Gloster *Javelin* and English Electric P.1B fighters are armed with *Firestreaks*.

Another interesting point is that there is today a more or less smooth transition from the interceptor, which launches its air-to-air rockets, to the anti-aircraft rocket, in which warhead and carrier are combined in a single unit. Such transition is provided by the planned remote-control version of France's *Trident* interceptor on the one hand, and by America's *Bomarc* surface-to-air missile, carrying separate *Falcon* air-to-air rockets, on the other.

All the air-to-air weapons shown in Paris have at any rate completed their development stage and are now undergoing operational testing or are considered to be already operational. Consequently the Royal Air Force has recently introduced a new trade, known as Guided Missile Fitter, and has commissioned test equipment for missiles, such as the Operational Airfield Test Set made by Fairey for the *Fireflash*.

*

Secondly, *surface-to-air missiles* are replacing manned fighters to an increasing extent. For example, Britain has put the *Thunderbird, Bloodhound* and *Sea Slug* into production and appointed a senior officer to coordinate the guided weapons organization and the radar warning system. Operational coordination is very necessary, since even the missiles within the short-range category vary considerably in range and purpose. For example, the rocket-powered English Electric *Thunderbird* has a shorter range than the Bristol/Ferranti *Bloodhound* with its two ramjets. The former, like France's *Parca*, will probably go to the Army to replace conventional anti-aircraft artillery. The greater the range, the more closely anti-aircraft missiles must be coordinated with other air defence means. In the extreme case of the *Bomarc* there is even talk of ranges around 245 nautical miles.

*

Surface-to-surface missiles for ground combat seen in Paris were typically representative of weapons for two fundamentally different tasks. On the one hand, the SS.10 is designed for combat ranges of from 200 to 1,700 yards, while the SE.4200 has a range of roughly 55 nautical miles. Both weapons, however, have powerful warheads and very accurate guidance systems.

The operational simplicity and flexibility of the SS.10 will doubtless lead to a complete revision of traditional methods of anti-tank warfare. Launching procedures are manifold and in some cases astonishingly simple. If necessary, the SS.10 can be fired direct from its transport container, though normally it is launched from a jeep or helicopter. Time required to prepare for launching is practically zero, even when targets appear unexpectedly. The reason is that the launching equipment does not have to be aimed in the same way as an ordinary gun barrel. Because of the high accuracy of the command guidance system—four out of five missiles launched really hit their target—the cost of tank destruction is relatively low. It is therefore understandable that the military should have shown considerable interest in this new weapon and that large numbers should have been ordered both by France and by other countries. It also seems obvious that the weapon will influence the technical development of tanks.

In general terms it can be said that the introduction of tactical surface-to-surface weapons to replace artillery must lead to drastic changes in services organization. In particular the qualities attributed to the SE.4200 will probably demand far-reaching modifications in inter-service responsibilities.

*

Even greater consequences—affecting an incomparably wider field of military planning—will result from the advent of the *long-range strategic missile* of the Northrop *Snark* category, as well as the tactical/strategic missile à la *Matador*.

The U.S.A.F.'s TM-61 *Matador*, the first tactical missile of substantial range—though perhaps not altogether suited to Western European requirements—is already in squadron service. Capable of operation with a variety of guidance methods and military loads, it opens up many new tactical and strategical possibilities. It has become the "forefather" of five similar missile programmes at Martin and also heads the list of all aerodynamic missiles, i.e., of the "air-breathing" or "cruise-type" missiles. The intercontinental *Snark* also belongs to this group.

The *SM-62 Snark* is in practice the first, almost operational, surface-to-surface missile with intercontinental range. It can almost certainly be brought up to operational status far more quickly than the *Atlas* or *Titan* ballistic missiles or the ramjet-powered vehicles of the SM-64 *Navaho* category.

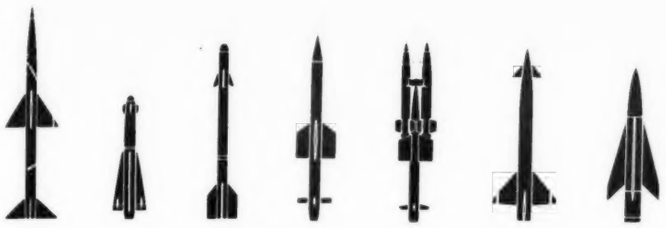
However, it seems unlikely that the optimum strategical formula will be agreed upon in the near future. Each of the present projects has its supporters, and not infrequently it is more or less sentimental considerations that tip the scale. In my view, the aerodynamic missile has the advantage not only of shorter development times, but also of smaller dimensions and lower weight . . . not to mention its greater accuracy. The results are lower costs and greater strategic mobility. For example, only two C-124 transports were needed to carry the *Snark* and its launching ramp across the Atlantic.

It is probably for these reasons that the *Snark*—despite its detractors—has been ordered in substantial numbers and is expected to be in operational service by the end of 1958.

*

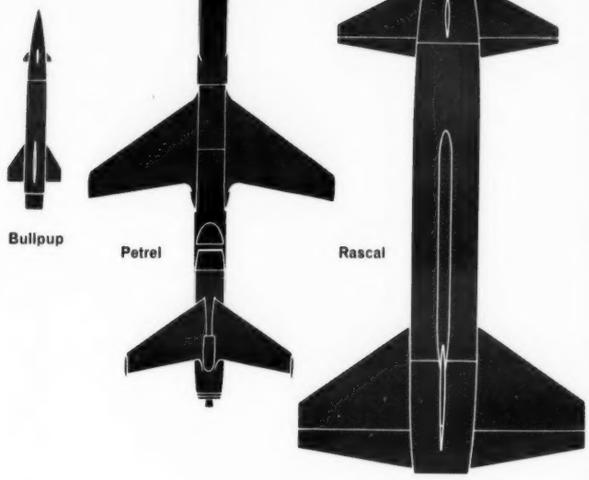
Finally, it should be recalled that the guided missiles shown at Le Bourget incorporated very varying technical solutions, as regards both their aerodynamic design and their propulsion and guidance systems. Particularly marked differences were visible among the air-to-air and surface-to-air weapons. All of which tends to confirm—if confirmation were needed—Professor von Karman's statement of two years ago: "Guided missiles open a new era in aeronautical development".

AIR-TO-AIR WEAPONS



Sparrow I · Falcon · Sidewinder · Firestreak · Fireflash · MATRA 510 · Nord 5301

AIR-TO-SURFACE WEAPONS



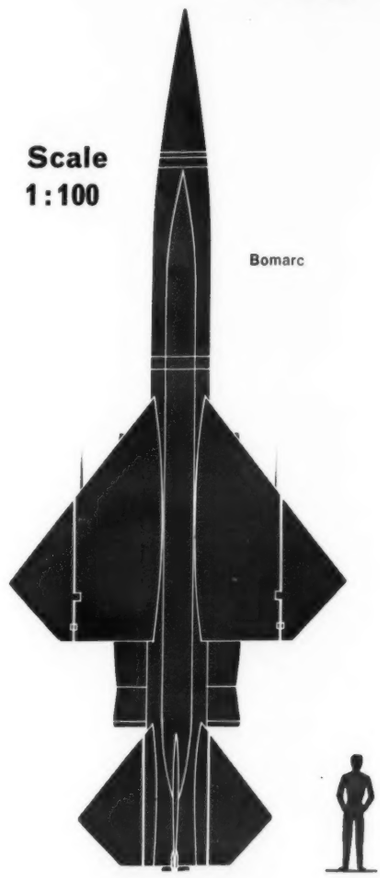
Bullpup · Petrel · Rascal

The West's Guided Missiles

Robot weapons in the form of specialized weapons systems are steadily gaining ground in almost every variety of military operation. Whereas in the 1951 fiscal year, the United States spend only roughly $21,000,000 on missiles procurement, total expenditure in the 1958 fiscal year (which began on July 1st, 1957) may well reach $2,000,000,000, according to estimates published by the Aircraft Industries Association of America. Thus, in the space of seven years, guided missile appropriations have increased almost a hundredfold, while military aircraft procurement funds have not even been trebled (from $2,400,000,000 to $6,700,000,000). Nevertheless, despite this rapid increase, the 1958 guided missiles appropriations still represent only 35% of the total spent on military flying equipment. By 1961, however, aircraft and missiles will each get 50% of the procurement funds . . . after which the robot will probably outpace the piloted aircraft.

This revolution in weapons techniques is a costly affair. In the United States alone, the 1958 budget allows roughly $332,000,000 for guided missiles research and development, compared with "only" $276,000,000 for research in the conventional aircraft field. It should also not be forgotten that the American missiles now in operation (*Nike, Corporal, Matador, Sparrow, Terrier,* etc.) were projected immediately after the war; in other words, it took them nearly ten years to reach the operational stage. The wide variety of types available is due above all to the many different special tasks envisaged for missiles right from the initial design stage. Military requirements obliged designers constantly to seek new configurations, guidance systems and operating methods.

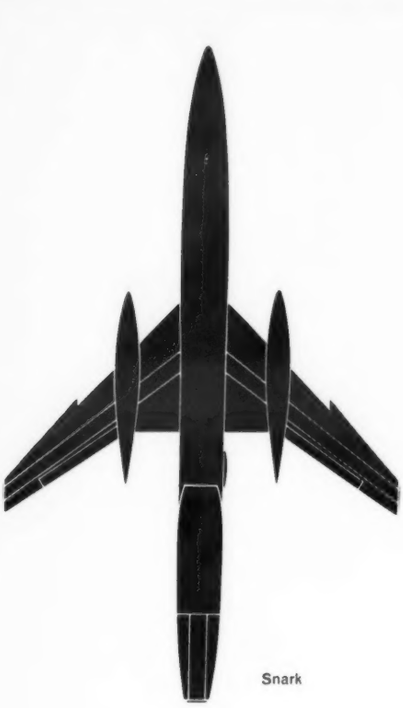
Scale 1:100



Bomarc

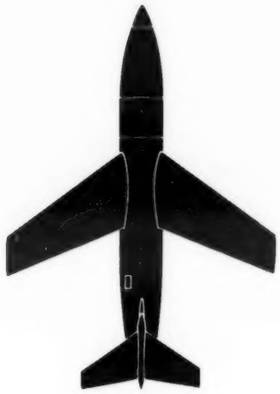
SURFACE-TO-AIR WEAPONS

Nike-Hercules · Nike-Ajax · Terrier · Talos · Bloodhound · Thunderbird · PARCA · SE 4300 · Oerlikon 54



Snark

Regulus II



Matador C

SURFACE-TO-SURFACE WEAPONS

(Aerodynamic missiles)

Lacrosse

SE 4200

Scale 1:200

The scale drawings on these pages—and the table immediately following—reveal the present status in missile engineering in the major Western countries. Operational weapons are shown as black silhouettes, types still under development, but where production is planned or has already begun, as grey outlines. The survey does not include prototypes or development models for which insufficient information on dimensions or configuration is available (e.g., the *Polaris* and *Jupiter* surface-to-surface weapons, the *Tartar* and *Hawk* surface-to-air missiles, etc.) even though they may be approaching the production stage. Experimental and research rockets have also been omitted from both drawings and table.

*

America's lead in the missile field is clearly revealed. While Britain and France approached the development of missiles only halfheartedly in the immediate post-war years, all three services in the United States were tackling the problem energetically. After bitter controversy between the U.S. Army and the U.S.A.F. as to who should control the long-range rockets, the Air Force finally embarked upon the biggest engineering project undertaken since the atomic bomb, namely the Intercontinental Ballistic Missile with hydrogen warhead. The U.S.A.F.'s Air Research and Development Command assumed overall supervision of the *Atlas* project (whose technical execution is in the hands of Convair and North American).

All three U.S. services are working on medium-range missiles, the Army on the *Jupiter* project, the Navy on the *Polaris*, and the Air Force on the *Thor*. There are still no details available on the development status of any of these three I.R.B.M.s.

France and *Britain* initially concentrated on air-to-air rockets and surface-to-air weapons for use against high-flying raiders. Substantial efforts have been made, particularly during the past two years, to develop these weapon categories into effective adjuncts to the national defence systems. Both countries are also to get American surface-to-surface missiles under the N.A.T.O. arms aid programme. Meanwhile, Britain has now begun work on an I.R.B.M. of her own design.

*

Each of the missiles shown forms, together with its transport vehicle, launching equipment, guidance centre and test equipment, an integrated whole—a *weapons system* whose efficient operation can be ensured only by a reliable industrial organization and by highly-trained crews. In this connection it should be stressed how smoothly the American industry, in particular, has overcome initial difficulties in the production of guided missiles, with parts being manufactured in dustfree, temperature-controlled shops, stringent supervision of spares inventories, etc. It is only necessary to recall that a large guided missile contains some 300,000 parts, to realize the extent of the laboratory facilities and field test equipment required.

SURFACE-TO-SURFACE WEAPONS

(Ballistic missiles)

Atlas

Redstone

Corporal

Honest John

THE WEST'S GUIDED MISSILES

Manufacturer	Type designation	Country	Propulsion unit + (boosters)	Thrust + (thrust of boosters) lbs. + (lbs.)	Length ft. ins.	Launching weight lbs.	Range or ceiling nm or m	Max. speed, Mach number or knots	Guidance system	Remarks
AIR-TO-AIR										
MATRA (Société Générale de Mécanique - Aviation - Traction)	M.04	France	SEPR.251 liquid rocket motor	2760 lbs/ 14 sec	15′	210 lbs	—	Mach 1.5	—	Test model (scale 2 : 3) for air-to-air rockets.
MATRA	M.20	France	SEPR.251 liquid rocket motor	2760 lbs/ 14 sec	≈ 15′	—	≈ 1600 m	Mach 1.5	—	In production; for use on *Mystère IV* etc.
MATRA	M.051	France	Two-stage solid rocket motor	—	≈ 9′10″	350 lbs	—	Mach 1.5	Beam guidance or homing head	In production for *Vautour*.
MATRA	M.510	France	Two-stage solid rocket motor	—	≈ 9′ 10″	350 lbs	—	Mach 1.7	Optical homing head	Also M. 511 for *Trident II*.
SNCA du Nord/ SFECMAS	Nord 5103	France	Solid rocket motor + (solid booster)	—	8′ 2″	300 lbs	≈ 4000 m	Mach 1.7	Radio guidance	In production.
SNCA du Nord/ SFECMAS	A.A.10	France	—	—	—	—	—	—	—	—
Fairey	Fireflash	Gt. Brit.	2 solid rocket motors	2 × 1100 lbs	≈ 9′ 7″	—	≈ 2000-3000 m	Mach 2	Beam guidance	In production and operational testing (R.A.F.). Plessey and E. K. Cole participate in development and production.
de Havilland	Firestreak	Gt. Brit.	Solid rocket motor	—	7′	—	—	Mach 2+	Infra-red homing head	In production (for R.A.F. and Navy), Mullard participating in development and production; for P.1B, *Javelin*, *Sea Vixen* and P.177.
Douglas	MB-1 Genie	USA	NAA-Rocketdyne liquid rocket motor	—	—	—	—	—	Hughes guidance system	Under development for U.S.A.F.; may have atomic warhead; to be standard equipment for F-89J, F-101B, F-106.
General Electric/ Philco	AAM-N-7 Sidewinder	USA	Solid rocket motor	—	9′ 2″	≈ 150 lbs	—	Mach 2.5	G.E.-Philco guidance; infra-red homing head	In production for Navy, U.S.A.F. (GAR-8) and in operation.
Hughes/Philco	GAR-1 Falcon	USA	Thiokol solid rocket motor	≈ 6000 lbs	6′	≈ 120 lbs	< 5.5 nm	Mach 2.8	Active homing	Operational with U.S.A.F.; latest Version GAR-1D; used on F-89H, F-102.
Sperry/Douglas/ Raytheon	AAM-N-2 Sparrow I AAM-N-3 Sparrow II AAM-N-4 Sparrow III	USA	Aerojet-General solid rocket motor	—	12′	300 lbs	≈ 5 nm	Mach 2.7	Sperry guidance system; *Sparrow I* = beam guidance; *Sparrow III* active homing	*Sparrow I* operational with Navy, II in production; III under development.
Shin Mitsubishi	MM-1	Nippon	Fuji Precision Co. solid rocket motor	—	≈ 5′	≈ 45 lbs	—	—	Beam guidance	Under development; Mitsubishi Electric Co. making electronic equipment.
AIR-TO-SURFACE										
A.V. Roe	—	Gt. Brit.	—	—	—	—	—	Mach 2+	—	Under development for R.A.F.; described as "stand-off bomb"; with hydrogen warhead; used by V bombers.
Bell Aircraft	GAM-63 Rascal	USA	Bell liquid rocket motor	≈ 6000 lbs	≈ 30′	≈ 13 000 lbs	—	Mach 1.5	Federal Telecom. Lab. guidance system	In production for U.S.A.F.; released by B-47, B-52 and (probably) B-58 near target.
Fairchild	AUM-N-2 Petrel	USA	Fairchild J44 jet	1000 lbs	24′	3800 lbs	—	Mach 0.7	Active homing	Against underwater targets.
Fairchild	AUM-N Goose	USA	Fairchild J83 or Gen. Electric J85 jet	2000 lbs	—	—	—	—	—	Under development for Navy; long range; against underwater targets.
Martin	ASM-N-7 Bullpup	USA	Aerojet-General solid rocket motor	—	≈ 11′	≈ 600 lbs	—	—	—	Under development for Navy; forerunner of operational *Bulldog*; canard design.
Sandia Corp.	AUM-N Lulu	USA	—	—	—	—	—	—	—	Under development for Navy; against underwater targets; nuclear warhead.
SURFACE-TO-AIR										
DEFA	PARCA	France	Liquid rocket motor + (4 solid boosters)	—	≈ 16′	≈ 2200 lbs	≈ 20,000 m	Mach 1.5	Beam guidance; proximity fuse	In production.
DEFA	MARUCA	France	—	—	—	—	—	—	—	—
DEFA	MASALCA	France	—	—	—	—	—	—	—	—
MATRA	—	France	—	—	—	—	—	—	—	Hitherto undesignated missile of canard design; solid-propellant booster used.
Sud-Aviation	SE.4100	France	Bi-propellant liquid rocket motor	—	—	—	12,000 m	Mach 0.8	—	Experimental.
Sud-Aviation	SE.4300	France	Bi-propellant liquid rocket motor + (booster)	—	≈ 18′	≈ 2200 lbs	—	—	—	Limited production; designed for test purposes and as training and transition weapon.
Armstrong Whitworth	Sea Slug	Gt. Brit.	Armstrong Siddeley liquid rocket motor + (4 solid boosters)	—	≈ 20′	—	≈ 35 nm	Mach 3+	Semi-active homing	In production for Royal Navy; triple launchers for *Sea Slug* aboard the *Girdleness*; to be standard armament for four missile ships of the *County* class. — Participating in production: GEC, Sperry, John Thompson Conveyor Co., Sir George Godfrey, Vickers, Metro-Vick, McMichael Radio, EMI and ICI.
Bristol/Ferranti	Bloodhound	Gt. Brit.	Two *Thor* ramjets + (4 solid boosters)	—	25+′	—	40+ nm	Mach 2+	Semi-active homing	In production for R.A.F.; to be U.K.'s standard anti-aircraft missile.
English Electric/ Marconi/Napier	Thunderbird	Gt. Brit.	Napier solid or liquid rocket motor + (4 solid boosters)	—	20+′	—	35 nm	Mach 3+	Semi-active homing	In production for Army; Marconi guidance system; for operation from fixed or mobile launchers. Later development for R.A.F. possible.

Manufacturer	Type designation	Country	Propulsion unit + (boosters)	Thrust + (thrust of boosters) lbs. + (lbs.)	Length ft. ins.	Launching weight lbs.	Range or ceiling nm or m	Max. speed, Mach number or knots	Guidance system	Remarks
SURFACE-TO-AIR *(cont.)*										
Contin-O.T.E. (Costruzioni Meccaniche Aeronautiche Angelo Contin & Officine Toscane Elettromeccaniche)	M.R.27	Italy	—		—	—	—	—	—	Under development; O.T.E. responsible for electronic equipment.
Oerlikon/Contraves	Model 54	Switz.	Liquid rocket	≈ 2200 lbs/ 30 sec	≈ 16′	≈ 820 lbs	15,000-20,000 m	Mach 1.8	Beam guidance & proximity fuse	Model 56 is more advanced successor; Model 57 under development.
Bendix/McDonnell	SAM-N-6 Talos	USA	McDonnell ramjet + (solid booster)	—	≈ 16′	2500 lbs	≈ 40 nm	Mach 2.5+	Active homing (Internat. T. & T. development)	In production for U.S. Navy; also *Talos L* (U.S.A.F.) and *Talos W* (Army); operational by 1958.
Boeing	IM-99 Bomarc	USA	Two Marquardt ramjets + (Aerojet solid booster)	2×10,000 lbs	47′	≈ 8500 lbs	200-250 nm	Mach 2.5	Westinghouse Electric guidance	In production for U.S.A.F.; may carry GAR-1 *Falcon* missiles.
Convair/Motorola	SAM-N-7 Terrier	USA	Kellogg solid rocket motor + (solid booster)	—	27′	3350 lbs	≈ 20 nm	Mach 2.5	Beam guidance; Philco proximity fuse	In production and in service with Navy; also used by Marine Corps. Versions: *Terrier 1* and *2*.
Convair	SAM-N Tartar	USA	Solid rocket motor	—	—	—	—	—	—	In production; derived from *Terrier*, but smaller than latter.
Douglas/Western Electric	SAM-A-7 Nike-Ajax	USA	Aerojet/Bell liquid rocket motor + (solid booster)	2600 lbs	35′	≈ 3000 lbs	≈ 20 nm	Mach 2.1	Bell command guidance (beam guidance for last portion of trajectory)	Operational (U.S. Army).
Douglas/Western Electric	SAM-A Nike-Hercules	USA	Liquid rocket motor + (solid booster)	—	41′ 6″	≈ 10,000 lbs	≈ 35 nm	≈ Mach 2.5	—	In production; improved performance compared with *Nike-Ajax*. Can carry atomic warhead.
Northrop/Raytheon	SAM-A Hawk	USA	Solid rocket motor	—	≈ 16′	—	≈ 45 nm	—	Active homing	In production for Army and Marine Corps; against low-flying aircraft.
TACTICAL SURFACE-TO-SURFACE MISSILES (short and medium range)										
DEFA	ENTAC	France	Solid rocket motor	—	—	—	≈ 1600 m	≈ 160	Wire command guidance	Anti-tank weapon; in production.
Sud-Aviation	SE.4200	France	Ramjet + (2 solid boosters)	—	≈ 10′	660 lbs	55-60 nm	< Mach 1	Radio guidance	In production; launched from short ramp.
SNCA du Nord/ SFECMAS	SS.10 (SFECMAS 5202) (SFECMAS 5203)	France	Solid rocket motor	—	2′ 10″	33 lbs	≈ 0.9 nm	≈ 160	Wire command guidance	Anti-tank weapon; in production and service; export. Can also be launched by helicopters. Type 5202—training version; type 5203—operational version.
SNCA du Nord/ SFECMAS	SS.11 (SFECMAS 5210)	France	Solid rocket motor	—	≈ 4′	—	1.9 nm	≈ 380	Wire command guidance	Derived from SS.10; in production.
Fairey (?)	—	Gt. Brit.	—	—	—	—	—	—	—	Anti-tank weapon; under development for Army. Also for air-to-ground use.
Contraves-Oerlikon-Boelkow	Cobra 4	Switz.	Solid rocket motor	—	—	≈ 24 lbs	≈ 0.8 nm	≈ 160	Wire command guidance	Anti-tank weapon; further developments in hand.
Aerophysics Development/Utica-Bend	SSM-A-23 Dart	USA	Grand Central solid rocket motor	—	≈ 6′	≈ 300 lbs	≈ 2.7 nm	—	Wire command guidance	Anti-tank weapon; in production for Army.
Chance Vought	SSM-N-8 Regulus I	USA	Allison J33-A-14 jet + (2 solid boosters)	4600 lbs	32′ 6″	≈ 14,500 lbs	220 nm	Mach 0.9	Command guidance	In use for training etc.
Chance Vought	SSM-N-9 Regulus II	USA	Wright J65 jet (later G.E. J 79) + (2 solid boosters)	≈ 10,000 lbs +(2×33,000 lbs)	57′	≈ 35,000 lbs	—	Mach 1+	Sperry guidance	In production; substantial production contracts awarded.
Chrysler	SSM-A-14 Redstone I (Jupiter A)	USA	NAA-Rocketdyne liquid rocket motor	≈ 65,000 lbs	≈ 60′	≈ 40,000 lbs	< 200 nm	Mach 5+	Inertial guidance system	Can carry atomic warhead; navigation system by Ford Instrument Co., Sperry Rand.
Firestone/Gilfillan	SSM-A-17 Corporal	USA	Ryan liquid rocket motor	20,000 lbs	45′	≈ 12,000 lbs	≈ 40 nm	Mach 3.5	Motorola guidance system	Operational (Army); can carry atomic warhead; also *Corporal F.*
Martin	TM-61A Matador	USA	Allison J33-A-37 jet + (solid booster)	4,600 lbs +(50,000 lbs)	39′	≈ 12,000 lbs	≈350-400nm	Mach 0.9	Radio guidance	Operational (U.S.A.F.).
Martin/A.C. Electronics/Goodyear	TM-61B Matador	USA	Allison J33-A-39 jet + (solid booster)	4,600 lbs +(50,000 lbs)	≈ 45′	≈ 14,000 lbs	520 nm	Mach 0.9-1+	Inertial navigation system by A.C. Electronics Div. of General Motors and Goodyear	Operational (U.S.A.F.); TM-61C and TM-61D in production; can (like TM-61A) carry atomic warhead.
Martin/Cornell	SSM-A-12 Lacrosse	USA	Thiokol solid rocket motor	—	≈ 20′	≈ 3300 lbs	≈ 8-10 nm	≈ Mach 0.8	—	Expected to be operational with Army and Marine Corps in 1958; close support missile.
STRATEGIC SURFACE-TO-SURFACE MISSILES (long and extra long range)										
de Havilland (?)	— IRBM	Gt. Brit.	Reportedly by Rolls-Royce	—	—	—	1750+nm	—	—	Under development for R.A.F.
Chrysler	Jupiter IRBM	USA	NAA-Rocketdyne S-3 liquid rocket motor	154,000 lbs	—	—	1300+nm	—	Ford Instrument guidance system	Also *Jupiter C.*
Douglas	WS-315A Thor IRBM	USA	NAA-Rocketdyne S-3 liquid rocket motor	154.000 lbs	—	—	1300+nm	—	Guidance system developed by A.C. Electronics Div. (GM), Bell Telephone & Remington Rand	Under development.
Lockheed	Polaris IRBM	USA	Aerojet solid rocket motor	—	—	—	1300+nm	—	General Electric inertial guidance system	Under development for Navy.
Convair	WS-107A-1 (SM-65) Atlas ICBM	USA	NAA-Rocketdyne liquid rocket motor + (2 liquid boosters)	135,000 lbs + (2×100, 000 lbs)	≈ 100′	≈100,000 lbs	4300+nm	≈ Mach 15	Inertial guidance (Arma Div., American Bosch)	Under development for U.S.A.F.
Martin/Avco	WS-107A-2 Titan ICBM	USA	Aerojet liquid rocket motor	—	—	—	4300+nm	—	General Electric inertial guidance system	Under development for U.S.A.F.; two-stage model (stages in tandem).
Boeing (?)/ McDonnell	SSM-N-2 Triton	USA	2 McDonnell ramjets + (solid booster)	—	≈ 45′	≈ 20,000 lbs	≈ 1300 nm	Mach 3	—	Under development for Navy.
North American	SM-64 Navaho	USA	2 Curtiss-Wright ramjets + (NAA liquid rocket rocket motor)	2×≈ 30,000 lbs +≈ 100,000 lbs	—	—	4000+nm	Mach 3	Inertial navigation system	Development cancelled.
Northrop	SM-62 Snark	USA	P&W J57 jet + (2 solid boosters)	≈ 11,000 lbs +(2× 33,000 lbs)	≈ 70′	≈ 35,000 lbs	3000-3500 nm	Mach 0.9 - 1+	Celestial navigation & inertial navigation	In production for U.S.A.F.

Rocket Propulsion Units

by Engineer Vernet-Lozet

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The primary difference between rocket powerplants and other propulsion units is the fact that they do not require ambient air as either source of energy or flow substance; from this it can be deduced that the most appropriate application for rocket motors is the propulsion of aircraft, missiles and space vehicles in low-density air, i.e., at high altitudes.

No limits are set to the speed of a rocket-powered vehicle or the pressure inside the rocket by internal aerodynamic processes. Needless to say, this does not apply to turbine or ramjet engines, whose optimum efficiency is obtained only at a specific Mach number and a specific combustion chamber pressure. Ignoring the problems connected with the heat barrier, only the rocket propulsion unit today appears suitable for speeds of above Mach 4. In addition, rocket powerplants can be built with relatively high combustion chamber pressures (approx. 425 p.s.i.) so that greater thrust can be obtained than from other types of engine.

As rocket propulsion makes no use of the ambient air, not only the fuel but also an oxidizer, such as liquid oxygen or an oxygen compound, must be carried in the vehicle. The oxidizer can also be directly contained in the propellant mixture; e.g., solid propellants. The propellant supply for any rocket contains considerably more oxygen than carbon or hydrogen: for example, the complete combustion of 12 grammes of carbon requires 32 grammes of oxygen, while 2 grammes of hydrogen take 16 grammes of oxygen, etc.

The additional load of oxidizer which the rocket must carry is thus of particular importance: on the one hand the specific propellant consumption (fuel and oxidizer) is high, and on the other the propellant must provide sufficient energy to carry its own load. It is clear that rockets will be the most suitable propulsion units in cases where high, short-period thrusts are required, and this has been their main field of application in the past. In fact, almost all surface-to-surface and surface-to-air missiles have been launched by means of boosters using either solid or liquid propellants, which have accelerated the missiles to supersonic speeds within a few seconds.

The various types of rocket powerplant

Rocket motors fall into two main groups: *liquid-propellant* and *solid-propellant rockets*, depending on the physical properties of the propellant mixture.

In the first group, the liquid fuel and liquid oxidizer are fed to the combustion chamber by pumps or gas pressure, whereas in the second case solid propellant charges are prepared from a mixture of fuel and oxidizer; these burn away along specific surfaces, depending on their geometrical shape.

Ignoring the energy qualities of the various mixtures, it can be said that a liquid-propellant powerplant in which the propellant is fed by turbine-driven pumps can—assuming adequate cooling of the exhaust pipe and the combustion chamber—remain in operation for unlimited periods. Liquid-propellant powerplants in which the propellant is gas-fed to the combustion chamber and solid-propellant motors, however, have a limited operational endurance; on the one hand it is not possible to carry unlimited quantities of compressed gases (the weight of the container would become unacceptable) and, on the other, the burning speed of solid propellants, which depends on the chemical composition and the operating pressure, may not fall below a certain value.

It follows that liquid-propellant powerplants in which propellant feed is provided by turbine-driven pumps will be used primarily as main propulsion units for long-range rocket missiles, while the other two types are better suited for short-period, high-thrust operation, for example as take-off boosters.

Propellant mixtures

From the point of view of purely chemical reactions, there is no essential difference between the combustion of a solid-propellant charge and that of two liquids (fuel and oxidizer). In both cases a simple oxidation process is involved. From the practical standpoint solid propellants naturally offer certain advantages over liquid propellants: they are easier to handle and to store, are not corrosive and do not produce vapours likely to injure the human respiratory system, do not raise injection problems and are in general of greater density.

These propellant mixtures must, however, also have certain mechanical properties, so that they can be produced in suitable forms—if necessary by mass production methods. A solid propellant presents a compromise between the desired energy properties and certain limitations. For example, the efficiency of a classical, double-base solid propellant could be increased by altering the mixture ratio, but such an improvement must be paid for in the loss of mechanical properties. For the same reason the number of possible components is limited. Logically, therefore, development of solid-propellant rockets must be expected to be slower that that of liquid-propellant rockets.

Liquid propellants

The choice of liquid fuels and oxidizers is decided primarily by their energy properties and the proposed application of the rocket.

Ignoring air drag, the vertical speed gain of a rocket stage can be expressed as follows:

$$\Delta v = c \times log \frac{m_0}{m_1} - gt.$$

where c is the exit velocity of the gases, m_0 the launching mass, m_1 the mass on burnout, g the earth's mean acceleration and t the burning time.

The efficiency of a rocket is thus dependent primarily on the exit velocity of the gases and the specific mass of the propellant. From the above equation it can be readily deduced that these two parameters are of equal effect in the case of low Δv, while the exit velocity is preponderant at high Δv.

A space vehicle or intercontinental range strategic missile requires a propellant mixture of low specific consumption, as the rocket would otherwise be of impracticable size. On the other hand, a take-off booster or short-range rocket must represent the best possible compromise between specific mass and exit velocity.

Quite apart from these considerations, however, some thought must also be given to the projected operating conditions, which play only a minor role in the case of space vehicles. The latter will be launched only in small numbers, at pre-announced times and from fixed mountings. On the other hand, tactical rockets are designed for mass employment and must be ready for launching at any time, frequently under the most unfavourable conditions. Here safety questions play a preponderant part.

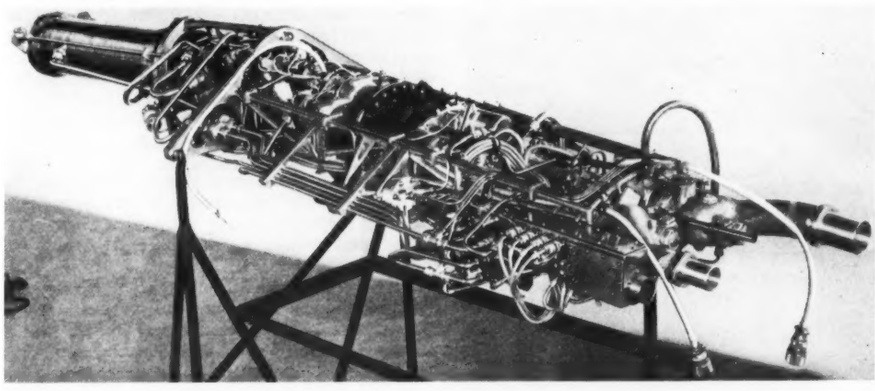
Finally, the choice of propellant mixtures is limited by the reaction conditions: a mixture whose combustion temperatures are of the order of 4,000°K must be eliminated from the start since the structural materials available today cannot withstand such temperatures.

Oxidizers

The main component of a propellant mixture is the oxidizer, not because it plays such an important part in the reaction, but because there are relatively few suitable substances and these vary considerably in their reaction capacities.

An examination of the periodic system of the elements reveals the best oxidizers to be oxygen and halogen fluorine. Although fluorine has certain advantages from the pure energy point of view, it is—as far as is known—used at best for test purposes, as a number of problems connected with its handling have not yet been solved. At present the oxidizer used in all operational

SEPR rocket motor of 3,300 lbs. thrust, with turbo-pumps for propellant feed. This engine is designed for installation in manned aircraft.



A SEPR solid-propellant rocket on the test bed.

rockets is oxygen or an oxygen compound, generally nitric acid or hydrogen peroxide.

Liquid oxygen

Pure oxygen has the lowest specific consumption of all oxidizers (with the exception of ozone, the manufacture and handling of which still present manifold problems). It is therefore particularly suitable for long-range strategic rockets. Its use in tactical rockets, however, is unadvisable, because of its high evaporation coefficient, which is also the only difficulty involved in storage. Pure oxygen is non-corrosive and non-toxic; it is produced—like liquid air—by conventional methods and costs only a few cents a pound.

Nitric acid

The specific propellant consumption when nitric acid is used is roughly 10% higher than for liquid oxygen *(Table 1)*. On the other hand, the density of nitric acid is relatively high (1.5 compared with 1.15). It is therefore better suited for medium or short range rockets. The manned *Trident*, designed for speeds of around Mach 2 and a few minutes flight on rocket power, the *Nike* surface-to-air missile and the *Aerobee* and *Véronique* special rockets use this oxidizer.

A particularly interesting property of nitric acid is its capacity for igniting spontaneously on contact with certain fuels, so that no special ignition system is required. These fuels include certain amines (aniline, xylidine, triethylamine, hydrazine), furfural alcohol and some pentagonal compounds, such as vinylether. For such a propellant mixture the ignition delay is of vital importance, i.e., the time elapsing between the mixing of the two propellants and actual ignition. This delay must be extremely short (at most 20 milliseconds), as the amount of propellant fed into the combustion chamber would otherwise be too large by the time ignition took place and a dangerous explosion would result.

On the other hand, nitric acid has the serious disadvantage that it corrodes most metals and has an irritant effect on the skin. Aluminium or stainless steel containers must be used for storage, and personnel handling nitric acid must wear protective clothing.

Hydrogen peroxide

The hydrogen peroxide used in rockets has a concentration of 85 to 90%. From the efficiency point of view it is comparable to nitric acid (see *Table 1*) and is thus used for similar applications.

	F_2	Liquid O_2	H_2O_2 (85 %)	NO_3H
Kerosene		3.92	4.34	4.33
Triethylamine				4.16
Hydrazine	3.35	3.66	4.14	4.02
Dimethyl-hydrazine		3.77		
B_2H_6		3.44		
B_5H_9		3.77		
$LiBH_4$		3.44		

Table 1—Specific consumption (in kg/secton) for various propellants, with a pressure ratio of 25 : 1. — The values given [1] are for optimum mixture ratios, assuming that equilibrium is maintained during expansion.

The stronger the concentration of this liquid, the less stable it becomes. Catalysers such as platinum sponge, special earths, calcium or sodium permanganate dissolved in water, produce or accelerate decomposition. This quality has also been utilized in rockets employing hydrogen peroxide as the sole propellant. If decomposition is provoked under pressure, by means of a catalyser, the result is super-heated steam and free oxygen which produce thrust as they are released (Walter T.500, de Havilland *Sprite*, etc.). Hydrogen peroxide is more difficult to store and handle than nitric acid because of the explosion hazard, though it is less corrosive and toxic. The latter fact, however, is less important in rocket weapons than in manned space vehicles.

Fuels

The above oxidizers can be used in conjunction with a large number of fuels, of which organic chemistry has an inexhaustible reserve.

If high thrusts are required, i.e., high exit velocities, gas mixtures with a high specific volume (or small molecular mass) must be used. Steam would thus be preferable to carbon gases, which explains the interest in organic compounds with a high hydrogen content, provided that the latter have roughly similar combustion temperatures. Pure hydrogen has the lowest specific consumption, but its low density is a disadvantage since it would necessitate excessively large containers being carried aboard the vehicle. Other interesting oxidizers: pure hydrazine N_2H_4 and dimethyl-hydrazine $N_2H_2(CH_3)_2$.

In practice the fuels used in conjunction with liquid oxygen or hydrogen peroxide are primarily kerosene or other petroleum distillates, as well as certain fatty alcohols, while nitric acid is burned with the above-mentioned substances which ignite spontaneously on contact with the acid. These fuels, however, are a great deal more expensive than kerosene, particularly as no big industrial plants exist for their production. Kerosene can also be used with nitric acid, when a spontaneously ignitable substance must be added for ignition purposes. Although this solution requires an extra propellant tank compared with the hydrogen peroxide/kerosene mixture, it has aroused considerable interest for safety reasons.

In addition to the organic fuels, boron/hydrogen compounds with similar properties to the organic compounds, especially in the form of B_nH_{+4} and B_nH_{+6} are now being studied. These derivatives have much lower specific consumption, with the same oxidizer, than the carbon derivatives. Interesting as these products may be, they cannot be expected to come into immediate use: their manufacturing cost is very high and they are dangerous to handle.

At present it looks as if the following fuels supply the best compromise between the various requirements: dimethyl-hydrazine, triethylamine (pure or mixed), furfural alcohol and kerosene.

Solid propellants

The oldest propellant mixture known is black powder. From the Middle Ages up to the discovery of nitroglycerine in the nineteenth century, it was the only explosive. Its original composition (potassium nitrate, carbon and sulphur), described, for example, by the Englishman Roger Bacon in the thirteenth century, was only slightly improved. Today it is used only as a fuse mass.

Until a few years ago the double-base nitroglycerine/nitrocellulose mixture dominated the solid propellant field. In this mixture the liquid nitroglycerine on the one hand plays the part of binder and on the other is the component with the highest energy. By increasing the nitroglycerine content the specific consumption can be reduced, but this is accompanied by an increase in the combustion temperature and a reduction in the mixture's mechanical properties.

Propellants of this type (e.g., SD and balistite) are still used and are perfectly well suited for powering small rockets. It is, however, not possible to make big propellant blocks, as the manufacturing presses are not sufficiently powerful.

During recent years a new solid propellant based on perchlorates has been introduced. The oxidizer, in grain form, is embedded in synthetic resin, which acts as fuel. This mixture can be cast into blocks of any required size, thus permitting simple and economical production. The future of solid propellants for rocket propulsion depends to a great extent on the development of such mixtures. It may be that the progress that can be expected from the introduction of boron derivatives in the liquid propellant field will also have repercussions on solid propellant development.

Combustion problems with solid propellants

As already mentioned, a compromise must be accepted, in the manufacture of solid propellant charges, between energy properties on the one hand and certain restrictions that have to be respected on the other.

The composition of solid and liquid propellants is limited by the combustion temperature. In practice rocket pipes are never cooled, so that a temperature of 3,200 to 3,500°K may not be exceeded. Similarly, specific consumption must

[1] Calculation of these figures is based on numerical values and constants taken from the book " Constantes thermodynamiques des gaz aux températures élevées " by Ribaud and Manson.

also be taken into account in deciding on composition (*Table 2* shows the specific consumption of selected conventional solid propellants for a pressure ratio of 50 : 1).

A further decisive parameter is the burning velocity. It is known to depend on pressure, but no generally valid formula for this relationship has yet been discovered. As a first approximation it can be said that burning velocity changes with the 0.4th to 0.7th power of the pressure (depending on the composition of the propellant mixture). Solid propellants in use today can attain burning speeds of roughly 4 to 5 mm/sec. In view of the research now being made in this field, values of some 2 mm/sec can be expected in the future, for operating pressures of approx. 355 p.s.i.

As specific consumption depends on the pressure ratio, it could be reduced by an appropriate reduction in pressure ratios, at least at low altitudes. This no longer applies to rockets operating at high altitudes, such as the final *Vanguard* stage. Ambient pressure in this case is practically zero, so that the combustion chamber pressure must be very small. This, however, would require over-large exhaust pipes, whose dimensions increase as combustion chamber pressure falls. Moreover, pressure on combustion of the propellant must not fall below a given value.

	SD (without solvent)	Balistite (J.P.N.)	Solid propellant based on ClO_4NH_4	Solid propellant based on NO_3NH_4	NO_3H + Kerosene at a pressure ratio of 20 : 1
Combustion temperature in °K	2,170	3,200	2,700	1,700	3,000
Theoretical exit velocity in m/sec	2,100	2,360	2,190	1,860	2,300
Specific mass in t/m³	1.59	1.61	1.75	1.55	1.32

Table 2. Characteristics of certain current solid propellants and liquid NO_3H/kerosene mixture. All data, except those in the last column, apply to a pressure ratio of 50 : 1.

Solid Propellant Rocketry

by John K. Elder

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A graduate of the California Institute of Technology, John K. Elder holds a degree in chemistry. Following graduation he spent four years in solid propellant research and development, before joining the staff of Grand Central Rocket Co., subcontractors on the third stage of the earth satellite launching vehicle, " Project Vanguard *". He currently holds a responsible post as Senior Staff Engineer with the company's Technical Services Division.*

Beginnings of modern solid propellant rocketry

In modern solid propellant rocketry, we are concerned primarily with two principal types of solid propellants. These are the *homogeneous or colloidal solid propellants*, and the *heterogeneous or composite solid propellants*.

The homogeneous solid propellants are single-phase chemical systems wherein the oxygen of the propellant is chemically bonded to the fuel, usually in the form of nitro or nitrate groups. Examples of this type of propellant are nitrocellulose (single-base propellant), nitrocellulose-nitroglycerine mixtures (double-base propellant), and diethylene glycol dinitrate.

The homogeneous propellants, being generally solids, are most readily processed into propellant charges by means of extrusion or molding techniques. However, through the use of solvents and plasticizers, many of the homogeneous propellant systems can be brought essentially into solution, cast into molds, and then " cured " by heating. The homogeneous propellants, especially the double-base systems, were widely used in solid propellant rocket applications during World War II.

The heterogeneous or composite solid propellants are multi-phase chemical systems. They consist of an intimate admixture of (a) an oxygen-rich compound termed the oxidizer, which is usually a crystalline, inorganic salt; (b) the fuel, a compound generally rich in carbon and hydrogen; and (c) other additives required for curing, stabilizing, burning rate catalysis, etc. Typical oxidizer salts are ammonium nitrate (NH_4NO_3), ammonium perchlorate (NH_4ClO_4), and potassium perchlorate ($KClO_4$). Typical fuels include asphalt, resins and synthetic rubbers.

An important requirement that solid propellant fuels must meet is the ability to bind the oxidizer particles together, and to impart to the composite system sufficiently good physical properties to withstand the stresses resulting from temperature gradients during extremes of ambient storage, then pressure gradients and acceleration during actual operation. For this reason, many solid propellant fuels are commonly and descriptively referred to as *fuel-binders*. Some compounds are good fuels, but lack binding potential; other compounds are excellent binders, but are not good fuels. The best propellant fuels, of course, possess both attributes.

Advantages of solid propellant rocket power

First and foremost, the solid propellant rocket is the simplest self-contained device conceived by man. There are no moving parts—no pumps, valves or turbines. A typical solid propellant rocket consists of three basic elements: the propellant charge, the motor case and the expansion nozzle. Also required for actual operation is the igniter, a small pyrotechnic charge, often inserted through the nozzle, which when actuated electrically, ignites rapidly to

The author (left) and Frank A. Marion, Director of Technical Services at Grand Central Rocket Company, with a two-stage supersonic solid-propellant rocket for high altitudes, consisting of a *Viper* (length 9 ft., thrust 6,000 lbs., burnout velocity 5,000 m.p.h.) and an *Arrow* (length 5 ft., thrust 2,300 lbs., burnout velocity more than 5,000 m.p.h.).

produce large quantities of heat. With an extremely short delay time, the igniter causes the surface of the propellant charge to ignite completely.

From the military aspect, the logistic characteristics of the solid propellant rocket are outstanding: instant tactical readiness, excellent storageability, little or no maintenance, low unit cost, high propellant density, no field storage or handling of hazardous fuels and oxidizers, and excellent adaptability to mass production techniques and quality control.

Commercial applications of solid propellants

Most of the commercial applications of solid propellants may be classified into two categories: the conventional solid propellant rockets, and the so-called gas generators.—In the *solid rocket* category are found JATO units, sounding rockets, sled propulsion rockets, research rockets, cloud-seeding rockets, fire-fighting rockets, lifesaving rockets, and sky-rockets. The *gas generator* applications include turbojet starters, auxiliary power units, oil well tools and fire extinguishers.

A typical *solid propellant JATO unit*, weighing about 150 lbs. loaded, will deliver 1,000 lbs. of thrust for a 15-second duration, and will reduce the sea level take-off distance of a DC-3, for example, by about 30%. The use of JATOs in commercial airliners may some day further increase the safety of air travel, expecially in the jetliner age.

Sounding rockets are being widely utilized in scientific investigations of the upper atmosphere. They will prove especially significant in connection with the 1957-58 International Geophysical Year, wherein concerted geophysical measurements of the earth and atmosphere will be made by scientific teams in all major countries of the world. The low-cost, solid propellant sounding rocket is designed to penetrate the upper atmosphere from a few miles to several hundred miles above the surface of the earth. Through the use of instrumentation contained within the rocket, accurate measurements of temperature, pressure, gas composition and radiation from outer space are made, and recorded or transmitted (telemetered) to receivers on the earth. These rockets, probing the fringes of outer space, will play an important role in the ultimate development of space-flight vehicles. It has been widely publicized that the final orbiting stage of *Project Vanguard* will be a solid propellant rocket.

Within the last five years, the use of *research sleds* traveling at subsonic and supersonic speeds has proven to be a highly efficient and economical means for the testing of aircraft and missile components under widely varying dynamic conditions. To achieve these high speeds on relatively short sled tracks, it is necessary to use rocket propulsion. The solid propellant rocket has demonstrated exceptional adaptability to this task because of the general characteristics of high reliability, high performance and low unit cost, and—more technically—because of such factors as high thrust-to-frontal-area ratios, high mass ratios, and ease of staging through programmed clusters of rockets.

Diagram showing operation of a solid-propellant rocket as used to clear clogged oil wells.

Another active area where solid propellant rockets are utilized is in the *research rocket* field. A prime example of this type of rocket is the HTV (Hypersonic Test Vehicle) which was designed and developed by the Aerophysics Development Corporation and the United States Air Force (WADC). The HTV, 12 feet in length and equipped with a two-stage power plant consisting of a total of eleven Grand Central Rocket Co. *Arrow* rockets, is capable of approaching a speed of 5,000 m.p.h. within two seconds. This imparts an acceleration of about 100 g to the HTV and all of its components. The HTV is used in research on rocket stability, aerodynamic heating and heat transfer problems at hypersonic speeds.

The solid propellant *gas generator* is a relatively new engineering concept and it is finding great utility as a self-contained " power-pack " in a wide variety of applications. A typical turbojet starter, for example, consists of a metal chamber in which a solid propellant charge burns. The high pressure combustion gases are then ducted from the chamber to a small, high-speed turbine which, through a gear train, initiates rotation of the main turbine. The entire turbo-starter unit is of very low weight. The propellant charge has excellent storageability and possesses instant operational readiness at all times.

Designed on the same principle as the turbojet starter is the *auxiliary power unit* which is used in applications where mechanical or electrical energy sources are required in compact, self-contained units. Such applications include piston actuators, seat ejectors, generator power sources, emergency standby power, etc. As with the turbo-starters, these units can be designed to be low cost, light-weight, rugged and highly reliable.—The gas generator principle is also used in the *oil well tool* illustrated and in fire extinguishers specially suitable for all types of small fires.

Future of solid propellants

Because of the extreme importance of simplicity and reliability in manned space vehicles, it is certain that the biggest future for solid propellants lies in the direction of outer space. The highest performance solid propellant rocket ever designed will soon accelerate the *Project Vanguard* satellite into an elliptical orbit about the earth at a velocity of some 18,000 m.p.h. Such a rocket, designed and developed by Grand Central Rocket Co., will probably play a significant role in the conquest of outer space.

In addition to their use as the prime propulsion for space vehicles, solid propellants will also be used as auxiliary power units for many types of free-space operations such as emergency moving and braking, propulsion for personnel and equipment, emergency standby power, free-space research rockets, lifesaving rockets and so forth.

One of Grand Central Rocket Co.'s eight " curing " ovens in which solid propellants are treated after being cast. The oven is 9 ft. in diameter and 30 ft. deep.

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Five Men in a Shack

ROCKETDYNE, to coin a phrase, is undoubtedly a major power in the land. The land—United States of America. The power—high thrust liquid propellant rocket engines. Major?—missile programmes including the U.S.A.F.'s Convair *Atlas*, Douglas *Thor*, North American *Navaho* and the U.S. Army's Chrysler *Redstone* and *Jupiter*.

It is a far cry from the humble beginning, only some eleven years ago, with a handful of engineers and scientists in a wooden shack on a parking lot at Los Angeles airport, to the present day complex of facilities and a payroll of 10,000 that comprise the 1957 *Rocketdyne* Division of North American Aviation, Inc. In 1946, when North American received a contract to develop a missile system, the Aerophysics Group was organized, and included a nucleus of five research engineers assigned to a propellant system study programme. At that time missile technology in the United States was practically non-existent and little or nothing was known about high thrust rocket engines. As a result of the knowledge acquired from the group's study of the German V-2—the first large pump-fed liquid propellant engine ever to reach production—North American received a contract to fabricate several engines based upon this design. The company developed this design to achieve greater power and more reliable performance and this was, essentially, the beginning of U.S.A. technology in the field of high thrust liquid propellant rocket engines.

Even in the early days it was clear that extensive testing facilities would be required to handle the enormous power developed by rocket engines. Thus in 1947, at a time when the majority of the country was still in a state of scepticism, North American explored, selected and financed a 600 acre site high in the Santa Susana mountains, and there established its Propulsion Field Laboratory. Today this project, now financed jointly by North American and the U.S.A.F, is the largest facility of its kind in the world. Ideally situated on 1,600 isolated acres of tumbled rock, small ravines and canyons, the site provides natural sound barriers; huge test stands designed to withstand over a million pounds of thrust are anchored in bedrock, and subsurface control centres with the latest instrumentation equipment, are supported by laboratories, machine shops, engine and maintenance facilities, the whole complex served by ten miles of paved roads and its own fire and police departments.

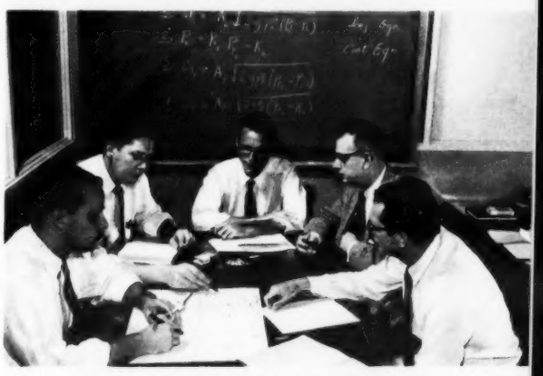
By 1950 the "Propulsion Group" had grown to 500 employees, and in 1953 the company's leadership in design and development resulted in a number of production orders for the first large rocket propulsion systems of American design. The expansion continued until in November 1955 some 3,500 scientists, engineers, technicians and production workers were involved in this operation. The growing importance of the project resulted in the creation of the *Rocketdyne Division* as a separate operating division of North American Aviation, Inc. Samuel K. Hoffman, who had directed the Propulsion Group's activities, was named as General Manager; at this stage Rocketdyne moved its main plant and offices from East Los Angeles and North American's facilities at Downey, Calif., to occupy its own new quarters at Canoga Park, Calif. Here the division now has a plant and offices area covering 316,000 sq.ft., with two additional buildings, an 84,000 sq.ft. Material Building and a 55,000 sq.ft. Engineering Building on a 40 acre site outside Los Angeles.

In the Spring of 1956 Rocketdyne began occupying its rocket engine production facility at Neosho, Missouri. Here 205,000 sq.ft. of manufacturing and office space will be used for the production of large liquid propellant engines supporting the operations at Canoga Park. Still under development this facility, the first in the U.S.A. devoted exclusively to rocket engine production, will reach 1,500 employees by Spring 1958, and will have its own test area for production engines.

In August 1955, a ten year mutual technical assistance agreement was signed with Rolls-Royce Ltd. of Great Britain, licensing that firm to manufacture rocket propulsion systems designed and developed by Rocketdyne. This agreement also provided for mutual exchange of technical information relating to engineering and development.

Today Rocketdyne is continuing research into advanced propulsion systems with extensive studies in the use of high-energy liquid fuels, such exotic systems as the Ion rocket, and other still highly security classified power plants which will provide power for outer space.

The Canoga Park, Calif., Administration buildings of the Rocketdyne Division of North American Aviation, Inc.

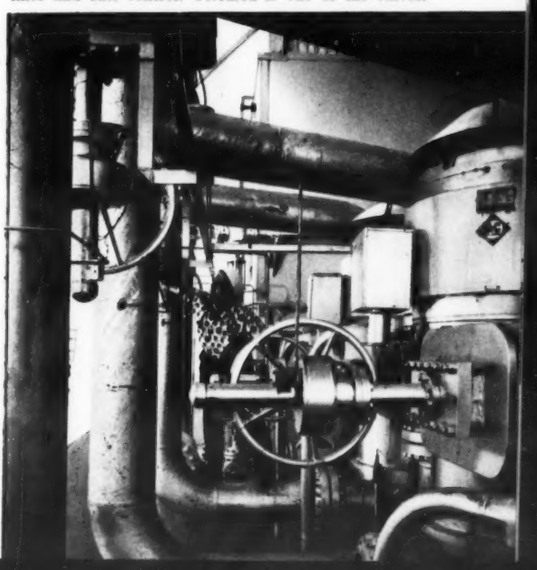


Rocket engine specialists and engineers frequently hold group conferences. Higher maths of course!

Precision engineering of rocket engine parts requires tolerances of 0.0001 in.; much of this work is carried out in a temperature controlled room at Canoga Park.

Liquid propellant rocket motors are "static-tested" anchored to huge steel and concrete test stands amidst the Santa Susana mountains, near Los Angeles.

Rocketdyne's High Flow Bench, the largest of its kind, uses water to test rocket engine thrust chambers, fuel lines and fuel control. Pictured is one of the valves.

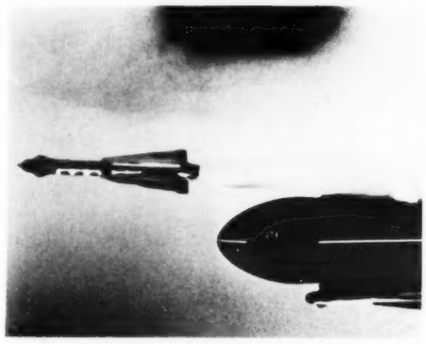


Left, a QB-17 disintegrates after a direct hit by rockets fired from a U.S.A.F. fighter-interceptor.

Air-to-Air Rocket Weapons

By Frederick I. Ordway, III,
Vice-President General Astronautics Corporation,
Huntsville, Alabama, U.S.A.

Three rather recent developments have emphasized the progress being made in the art of aerial warfare with guided weapons. One is *Infra-red guidance*, as used on the American Philco/G.E. *Sidewinder* and the British de Havilland *Firestreak*, another is the *Nuclear Warhead* now entering the operational area on the Douglas MB-1 *Genie* (first operational test over Nevada on July 19th), and the third is the *Bomber Defense Missile (B.D.M.)*.



Close-up view of the Hughes radar-guided *Falcon* missile immediately after launching from a U.S.A.F. Northrop *Scorpion*. Thiokol solid fuel motor with 6,000 lbs. thrust, range 4 miles, length 6 ft., weight 120 lbs. The F-89H carries six *Falcons* in wing-tip pods, supplemented by 42 rockets of 2.75 ins. calibre.

Infra-red Guidance

Infra-red was investigated primarily because of the limitations inherent in the more conventional detection systems. The greatest weakness of the earlier systems is the susceptibility to jamming, something which cannot be applied to infra-red guidance, although this does not imply that the latter cannot be "fooled" by extraneous or spurious heat sources.[1] Infra-red offers superior definition to radar, operating on something like a thousand times higher frequencies, and can discriminate or pick out an object much more accurately.

The Ryan MX-799 *Firebird* was the U.S.A.F.'s first semi-production guided weapon. Liquid propellant, with semi-active radar homing system and proximity fuse. Cruciform plastic wings, basic structure of aluminium alloy. Range approx. 5 miles. Length 7.5 ft.

An infra-red missile can be attracted by the jet exhausts of enemy bombers, or even by heat generated by aerodynamic friction. Bad weather will hamper somewhat the effectiveness of such a system (moisture attenuates and scatters infra-red energy), but in general it is an amazingly accurate guidance method, especially at high altitudes. It has been reported that infra-red guided *Sidewinders* have knocked flares off target drones, doing so little damage to the drone itself that recovery and reuse have been possible.

An advanced system Bomber Defense Missile (B.D.M.) has been developed by Cornell Aeronautical Laboratory.

It is necessary to convert the infra-red radiation of an airborne target into the lower frequency signals required for guidance. The first step is to bring the radiation into proper focus, commonly using parabolic collector antennas, and for the second step either thermal or photoconductor detection devices can be used; the former, using Bolometers, [2] is responsive to all infra-red frequencies, but must first change the energy into heat; the latter, operating on much less infra-red energy, responds much more rapidly than the thermal type, but suffers the disadvantage that it responds only to certain frequencies.

Infra-red fire control systems are now highly developed and often rely only on pinpoint heat-generating areas for detection. Once this has been achieved the interceptor's computer will automatically tie-in the armament system for the missile attack.

The introduction of every weapon and device immediately generates a counter-weapon and counter-device. For some time Servo Corporation of America has been working on its Airborne Gyrostabilized Infra-red Monochromator (A.I.M.), described as a complete radiation laboratory, capable of being mounted on bombers. Such a system will detect enemy interceptors, accumulate and analyze data on energy radiated from the plane (or missile fired from it), and will supply information on the spectral distribution of energy and spectral characteristics of the airborne target; the information gathered is presented in the form of a spectro-chart. A.I.M. is also being used as a research tool for the development of airframes offering minimum detection possibilities to opposing infra-red systems. It is known for instance that smooth, highly polished surfaces permit only a relatively small amount of infra-red energy to be radiated at any given temperature.

The Nuclear Warhead

During the past ten years much work has been put into guidance and fire control systems to ensure efficient launching, but warheads have been seemingly neglected, and many air-to-air missile operation research studies on kill probability have been made assuming fairly conventional warheads. But it should be borne in mind that the destructive power of the warhead is the only justification

[1] Russian tanks are reported to have extended exhaust pipes emitting heat that infra-red missiles home in on, missing the tank itself. Author.

[2] A very sensitive thermometric instrument of the metallic resistance type, used for measuring feeble radiation. Ed.

The *Sparrow Mk. I*, in service with the U.S. Navy, mounted on pylons under the wings of a McDonnell F3H-2M *Demon*. A beam rider weapon with semi-active homing, range 5 miles, solid propellant motor. Length 12 ft., weight 300 lbs.

A Swiss Air Force de Havilland *Venom* armed with Oerlikon 7-barrelled 8 cm unguided rocket launcher. (Oerlikon also produces 31 and 76-barrelled versions for 5 cm rockets.)

for air-to-air missiles, either guided or unguided.

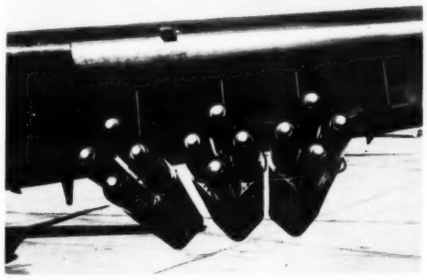
We now know that air bursts of atomic weapons produce a tremendous amount of kinetic energy in the form of blast or shock waves, and heat. Therefore, the introduction of the atomic tipped surface-to-air or air-to-air missiles would rule out mass bomber attacks. We may expect instead fairly wide spaced hit-and-run raids by fighter-bombers, or the use of the so-called "stand-off bomb" by high-speed, high-altitude bombers.

Atomic warheads for air-to-air missiles are capable of producing thermal, blast and radiation damage, and while we de not know the effective range of atomic tipped air-to-air missiles, such as the *Genie,* it is obvious that, if the lethal radius of the warhead is large, delivery must be made from a considerable distance. This implies a respectable range, and may explain the liquid propellant power units used, e. g. in the *Genie.*

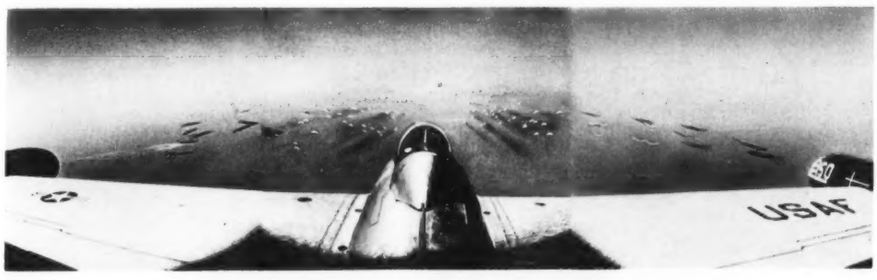
This does not mean that all air-to-air missiles will ultimately have atomic warheads. Just what warheads will be used for a given air-to-air missile will be determined by many factors such as the launching aircraft, the type of the missile guidance system and, of course, the target. One situation may require a fragmentation warhead, another a thermal warhead, while a third might even dictate some form of chemical warhead to destroy the crew, or interfere with the target's propellant system.

Highly accurate guidance systems have already largely altered the concept of aerial warfare, and the introduction of the atomic warhead may now largely complete the revolution. Observers are now closely watching tests being carried out on air-to-air atomic-armed missiles by the Atomic Energy Commission in Nevada, for further knowledge in this critical field.

The *Sidewinder* is in operational use with the U.S. Navy in the Mediterranean and Western Pacific. With infra-red homing system this weapon can destroy high performance type aircraft at altitudes from sea-level to 50,000 ft. Range 3 miles, calibre 4.5 ins, length 9 ft.



The *Zuni* high velocity rocket system in operational use with the U.S. Navy, designed for fighter and ground-attack aircraft. Solid propellant, calibre 5 ins, cost $65 (£ 23). Each launcher holds 4 rockets, can be jettisoned after firing, and is also used as the shipping case.



The older *Mighty Mouse* barrage rocket is probably still the major missile armament of American fighter aircraft. Composite picture from three cameras mounted on F-89 shows the terrific fire-power. Solid propellant motor with 800+ lbs. thrust, velocity Mach 2.7, weight 18.5 lbs., cost $65 (£ 23).

Bomber Defense Missiles

The idea of using air-to-air missiles for bomber defense is not new, but the problems of launching aft from a fast travelling aircraft have been so complex that, until recently, little progress has been made. In the United States the Cornell Aeronautical Laboratory has been particularly interested in the B.D.M., and has developed a fairly advanced system, about which few details are available (see photograph). North American Aviation also carried out a B.D.M. program, but this was later cancelled by the Air Force, for reasons which have not been made known.

Bomber armament, before the advent of guided aircraft rockets, had advanced to the point where it was very dangerous for conventionally armed fighters to make an attack. Flying the well-tried *lead pursuit course* into a bomber's defensive cone of fire became unfeasible. Modern fighters, equipped with automatic fire-control systems and missiles, now enter into a *collision course* approximately at right angles to the bomber's line of flight, release their weapons, and retire with minimum exposure to the concentrated fire pattern of the enemy.

For its part, the bomber has the problem of only being able to fire its defensive weapons for a very short period against the attacking aircraft, and must do so at crosswinds. Therefore armaments experts are now giving renewed attention to B. D. Ms.; they point out that the bomber has the advantages of space and carrying capability necessary to employ defensive missiles.

In the next few years we should see highly improved versions of the B.D.M., able to compete on favourable terms with such weapons as the modern rocket interceptor systems.

The Armstrong-Whitworth *Sea Slug* surface-to-air missile fired from H.M.S. *Girdle Ness*, the Navy's guided weapons trials ship.

The Bristol/Ferranti *Bloodhound* surface-to-air weapon immediately after take-off. This weapon is now in quantity production for the R.A.F.

The English Electric/Napier *Thunderbird* surface-to-air weapon, in model form, showing the interior construction. This weapon is in production for the Army.

Guided missiles

Britain's Guided Weapons

By Derek Wood, London Editor

A dramatic change in Britain's guided weapons potential has taken place in the year since *Interavia* last reviewed the missile art. Then, in 1956, only one air-to-air missile had been ordered, there was virtually no information available on ground-fired weapons, and the overall plan was heavily shrouded in the mists of security.

Since the publication of the Government's highly controversial White Paper on Defence, in April of this year, there has been an avalanche of technical papers, Government releases and press conferences. Compared with the single missile which was in production last year, there are today five, of which three are surface-to-air weapons, and two are air-to-air; in addition, at least a further three weapons, one surface-to-air, one anti-tank, and one I.R.B.M. are at advanced stages of development. Britain's first guided weapons station, Northcoates, has been opened, and the Royal Navy has commissioned the first guided weapons destroyer—albeit awaiting Armstrong-Whitworth *Sea Slug* weapons.

A basic defensive pattern has now been established with the Bristol-Ferranti *Bloodhound* medium range ramjet missile, using semi-active homing. One ring of bases for these weapons is to be constructed along the British Isles coastal perimeter, and others to defend specific vital areas. These will be operated by the new long-range radar warning chain, which is already in use, via the tactical control radar, and, finally, the fire-unit radars which will control the actual firings. Most of these processes will be automatic, and will involve the considerable use of computers.

The Army, particularly in overseas areas, will have the use of the English Electric / Napier *Thunderbird* which, mounted on vehicle drawn trailers and complete with radar van, is entirely self-contained. In its first stages the *Thunderbird* will be a shorter-range, higher-speed weapon than the *Bloodhound,* but with the same high degree of accuracy. The *Thunderbird* can use the same warning control set-up as the *Bloodhound.*

Both the *Bloodhound* and the *Thunderbird* are being evolved in stages, and they both have considerable development potential. The time lag between the stages will obviously vary in the two weapons and, thus, the Royal Air Force might acquire the second stage *Thunderbird,* if available at the right time, and then follow up with the second stage *Bloodhound,* etc.

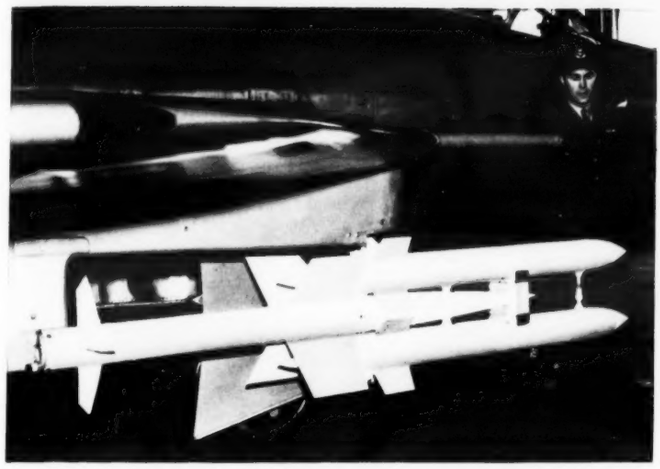
The development life of the weapons will cover a period of many years and, ultimately, they will be able to cope with high supersonic speed winged bombardment missiles and with stand-off bombs.

Parallel to the R.A.F. and Army programmes, the Royal Navy has been developing its own shipborne anti-aircraft missile, the *Sea Slug*. Test firings of the *Sea Slug* are being carried out from H.M.S. *Girdle Ness,* and this weapon will be standard for the defence vessels of the new carrier task forces.

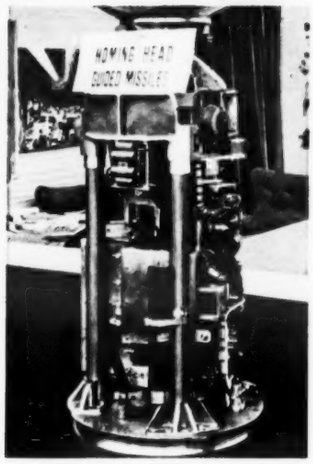
In the air-to-air category, the compact de Havilland *Firestreak* missile will be the standard weapon for R.A.F. and Naval fighter aircraft. It has a very accurate infra-red guidance system. As with the surface-to-air weapons, development will be in stages of increasing improvement in accuracy and performance.

The Fairey *Fireflash* beam-rider weapon is in full production, and in service for operational training on *Swift F.7s*; eventually it may be used on standard service *Hunters*. The *Fireflash* is the only air-to-air weapon so far available in the United Kingdom which can be used in cloud and rain and, for this reason, may be developed further for the low and medium altitude applications.

There is evidence to believe that more air-to-air weapons of exceptional range may be developed in the future, although these are likely to be larger than either the *Fireflash* or the *Firestreak*. In the past two years several projects have been abandoned, one of the most inter-



Now in service with the R.A.F. the Fairey *Fireflash* air-to-air beam rider weapon is shown mounted on a *Swift* F.7. This weapon may also be used on *Hunters*.



A radar homing head developed by Elliott Bros. for the Short general purpose test vehicles. Elliott are carrying out guidance and homing research on these weapons.

High altitude photograph, from the parent aircraft, of the de Havilland *Firestreak* air-to-air missile in flight and accelerating rapidly immediately after take-off.

esting being the massive weapon, code-named *Red Dean,* developed by Vickers; this weapon was intended for the thin-wing Bristol *Olympus* powered Gloster *Javelin,* but suffered a premature demise when the aircraft project was cancelled.

British firms are all set to sell air-to-air and surface-to-air defensive guided weapons systems to allied countries, and most recent discussions in the U.K. have centred upon the security classifications of the various missiles.

A great deal of theoretical work is now being undertaken by various firms and Government establishments, on the anti-I.C.B.M. missile; this represents an enormous task, but work so far carried out indicates that the project is feasible and, in fact, is nearer success than some people admit.

For the offensive role, the first stage beyond the free-falling nuclear bomb will be the air-to-surface supersonic weapon, now generally referred to as the "stand-off bomb". This type, under development by A. V. Roe Special Weapons Division, will be in the same class as the Bell *Rascal* and will extend the useful life of Britain's "V" bombers by several years. The Avro weapon, with hydrogen warhead, has replaced an earlier Vickers project for a guided bomb and will be the standard armament of the *Vulcan B.2* and the *Victor B.2,* when they come into service. It will have sufficient range to enable it to be air-launched outside normal radar ranges.

Meanwhile the Army will have the interim *Corporal* surface-to-air bombardment missile from the U.S.A., and, possibly, the American I.R.B.Ms, and these will fill the gap until later field weapons of U.K. development are available. In due course the R.A.F. will receive the British I.R.B.M., a weapon in the 1,500—2,000 miles range category; this project is well advanced and, according to foreign reports, the prime contractors are de Havillands for "airframes" and Rolls-Royce for the power plants. Over and above this, work is also going ahead on the British I.C.B.M. Both the I.R.B.M. and the I.C.B.M. involve a large number of firms.

Short Bros. and Harland G.P.V. (general purpose test vehicle) at the point of launch. These vehicles have been developed by Short under the guidance of the Royal Aircraft Establishment.

Another weapon at an advanced stage is the anti-tank missile, and, although no details of size, dimension or guidance systems are yet known, it is scheduled to become standard in the British Army, with various launching platforms available. Several other projects are still under the security blanket, and these include stand-off and anti-submarine weapons for the Royal Navy.

This then is the general picture of Britain's expanding weapons production and development, backed by the research establishments and firing ranges at Aberporth, Larkhill, Woomera and the Outer Hebrides. One thing, however, is far from clear, and that is the time phasing of airborne defensive missiles and stand-off bombs, as compared to automatic defence weapons and the I.R.B.M. and I.C.B.M. The full development of automatic defence will take many years, and the requirement for airborne missile carriers will not become clear until full scale exercises have been carried out; such tests would require batteries of weapons being used against high speed drone targets, at various altitudes, and having the full range of jamming devices.

Even if short-range defensive weapons do come up to expectations, it is still felt in some quarters that the long-range defence requirement, i.e. 100 miles plus from the coast, will devolve upon specialised missiles of advanced type, mounted on aircraft which will virtually be airborne weapon ships.

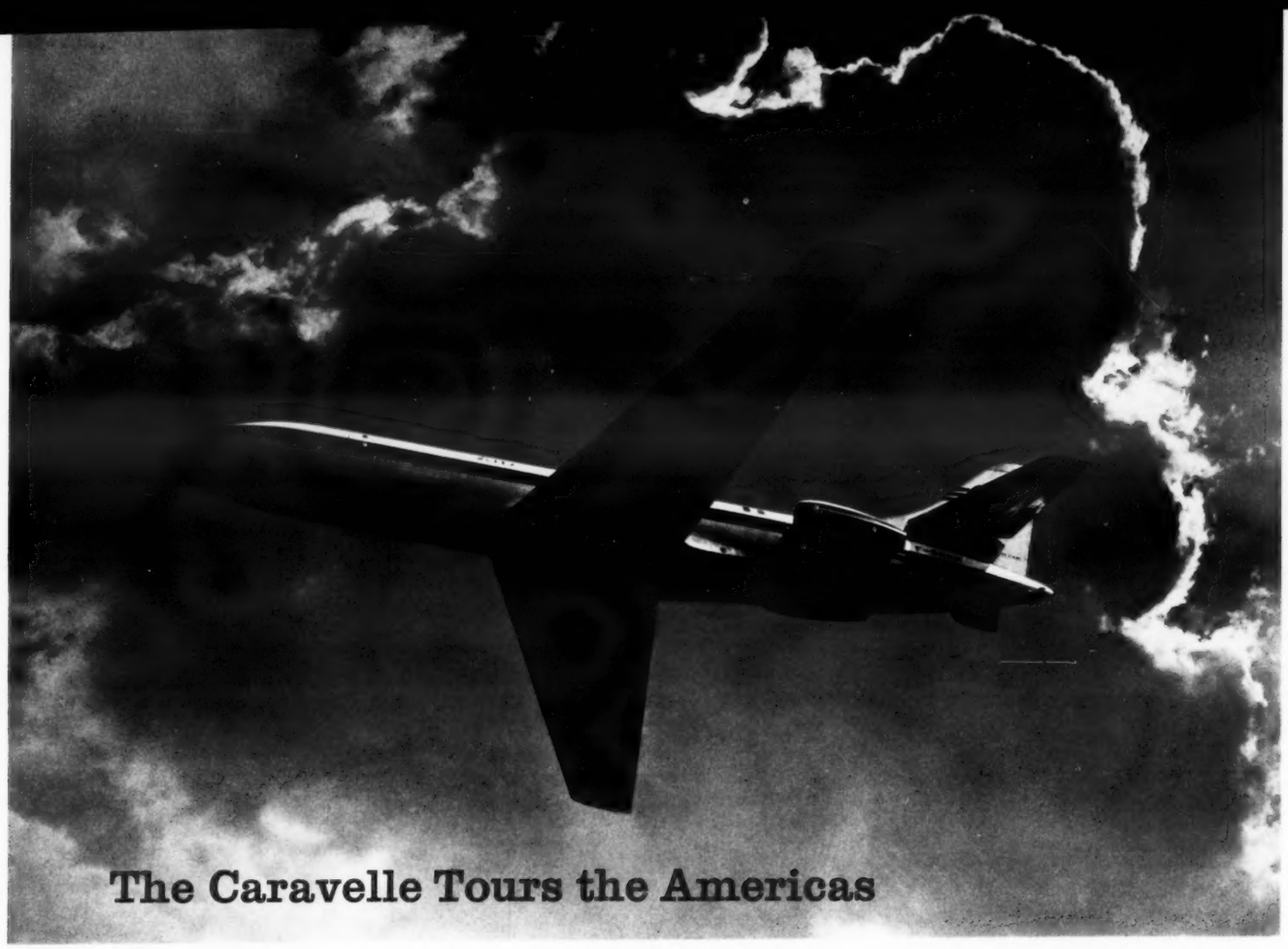
From the industry's point of view the past year has been a mixture of frustration and achievement. Some firms have seen one or more of their projects cancelled, with a resultant lack of development funds, while others have at last proved their "hardware" and now have the wheels turning to full production.

With the publication of the Defence White Paper and the Service Estimates, the bogey of mass purchases of U.S. defensive missiles and the subsequent run-down in the home industry has at last been laid, and the future programme is clear, if somewhat more restricted.

Unknown to the public at least half a dozen major weapons projects of diverse types have been embarked upon and abandoned in the eight years since the Ministry of Supply first approached industry to form consortiums for weapon development.

The teams now coordinating complete projects are Bristol, de Havilland, Armstrong Whitworth, Short Bros., A. V. Roe, English Electric and Fairey. English Electric remain the only complete team within one group (English Electric, Marconi, Napier), while others have one main partner, e.g. Bristol with Ferranti, and the remainder employ a complex of contractors round a central firm, as in the case of Armstrong Whitworth.

There is little doubt that the overall programme has achieved a considerable degree of success, and the ups and downs have produced several first class missile teams whose experience will stand them in good stead for tackling the next generation of projects.



The Caravelle Tours the Americas

An object lesson in punctuality, by Robert Blanchet, Paris

Preparations for the tour

When Sud-Aviation decided to make a demonstration tour of North and South America, as part of the sales promotion programme for its twin-jet, medium-range transport, the *Caravelle*, aeronautical pundits throughout the world greeted the announcement with scepticism. For the first time in the history of commercial aviation, a manufacturer was planning to send a prototype on a tour lasting more than two months, over routes where no special preparation had been made to receive it and which were situated more than 2,500 miles from its base. Moreover, the flight programme was so tight that it would inevitably be disrupted completely by the slightest technical failure in the aircraft. These facts were sufficiently obvious for most American reporters to describe the undertaking as hazardous.

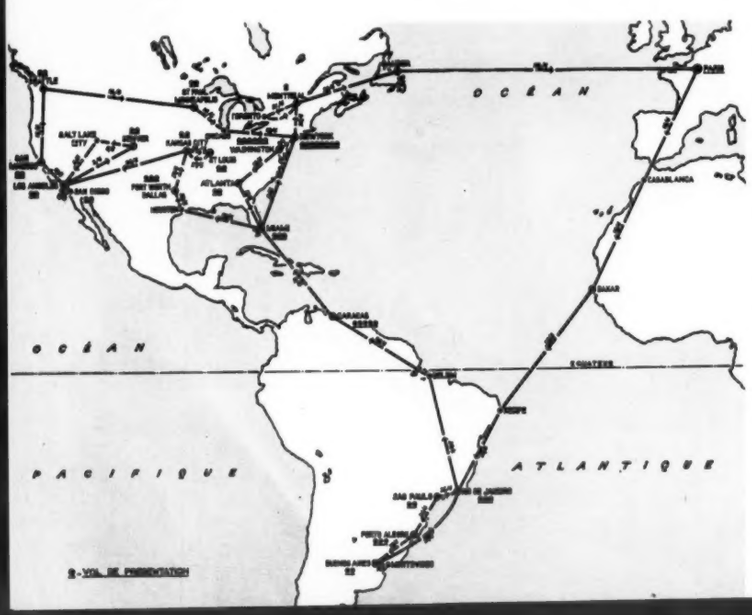
Though fully aware of all the pitfalls and possible snags involved in such a tour, the Sud-Aviation management was sufficiently encouraged by the results of Air France's 500-hour operational testing of the first prototype to ignore all warnings. A detailed itinerary was therefore mapped out to take in Brazil, Argentina, Uruguay, Venezuela, the United States and Canada between April 18th and June 25th.

Preparation of the tour was the major preoccupation of most of Sud-Aviation's staff for three months. Firstly, a technical flying crew capable of carrying out all current maintenance and the normal 50-hour and 100-hour inspections throughout the tour had to be assembled. This crew, composed of 14 technicians headed by a maintenance engineer, had to take along all the special tools it needed, as well as a set of spares sufficient to cope with any mechanical incidents likely to be encountered during the trip. So that the *Caravelle* could carry as many guests as possible on each stage of its journey, it was decided to send along with it a DC-4 to transport the maintenance personnel, tooling, spares and publicity material for distribution during the tour.

Throughout the trip the DC-4 faithfully accompanied the *Caravelle*, taking off half-an-hour behind it at every station and landing... sometimes several hours after it.

General instructions concerning the "sales" and "public relations" sides of the programme were issued by Paris, while local details were organized by Sud-Aviation's representatives in the various countries visited.

Route map of the *Caravelle's* tour of North and South America, from April 18th to June 25th, 1957. (Large dots symbolize the number of demonstrations made in the cities visited.)



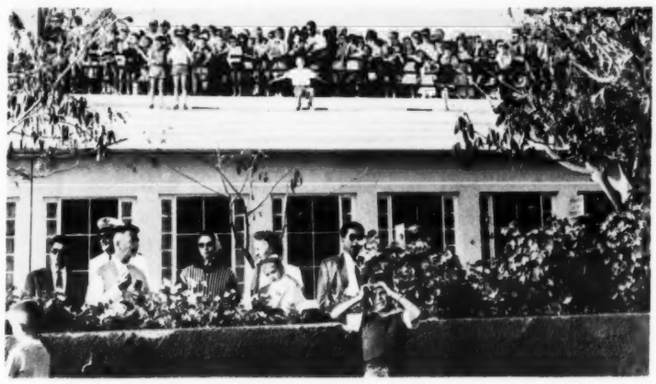
At Caracas: (left to right) Robert Pétin (Air France representative in Venezuela), Georges Héreil, Colonel Abel Romero.

At Washington D.C.: Brigadier General Claude J. Teyssier (Sud-Aviation's general representative in North America; left) and Chief Engineer Wieswold Jakimiuk (Sud-Aviation).

In Los Angeles: Kenneth G. Friedkin (second from right), President of Pacific Southwest Airlines, and Brigadier General J. Teyssier, with Air France and P.S.A. hostesses.

Henri J. Lesieur, Air France general manager for North America.

Caravelle demonstration flight at Buenos Aires, with guests.



On the airport roof . . . Dakar's "upper ten thousand" waiting for the *Caravelle*.

The actual tour

Despite the strike of Air France personnel at Orly and slight trouble with the aircraft's forward entrance door—difficulties which the whole Sud-Aviation crew swore would keep away bad luck during the tour itself—the *Caravelle* took off on its long demonstration trip as scheduled on April 18th, 1957.

Both the crew and those who stayed behind were well aware of the fact that the *Caravelle's* whole future depended on the success of this tour, and that the slightest mishap might bring discredit after the publicity given to the venture.

South America

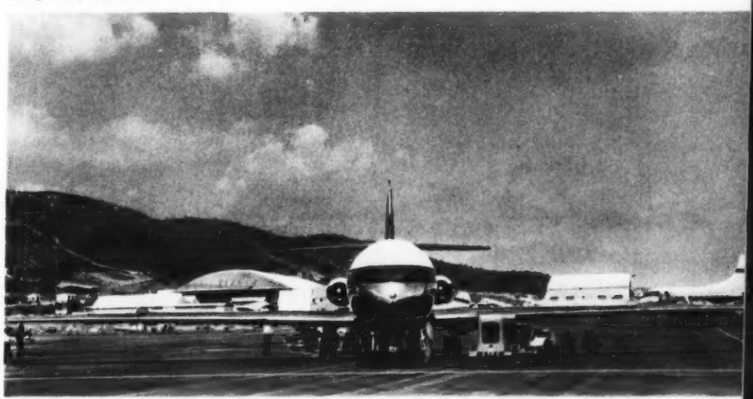
After a friendly call at Casablanca and another at Dakar, the *Caravelle* crossed the South Atlantic during the night of April 20th and made its first landing on the South American continent at Recife. This stage of 2,000 miles was covered in 5 hours and 22 minutes, despite an average headwind of over 30 knots. On arrival at Recife there were still 7,000 lbs. of fuel in the tanks, sufficient reserves for two hours stacking.

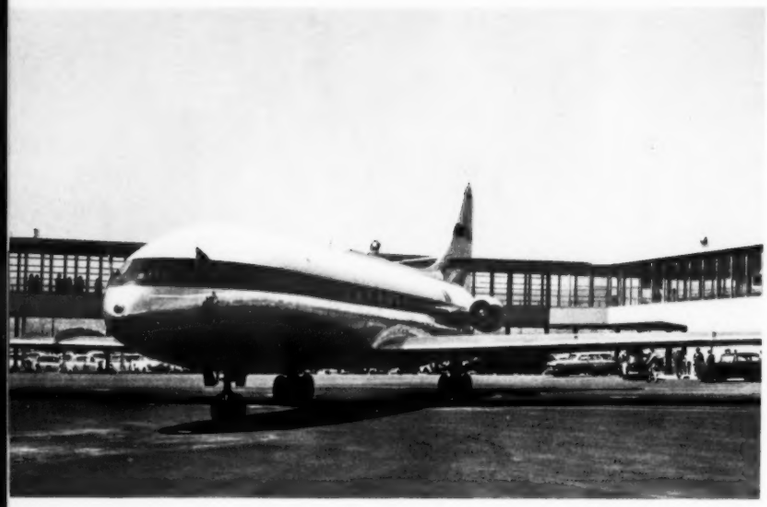
At Recife the aircraft had a foretaste of the enthusiasm which was to greet it at all its stops in South America. From dawn onwards dense groups of visitors came to inspect it at Guararapos airport. Inaugurating a practice that was to become standard throughout the tour, some thirty guests had been invited to travel to Recife by the normal air services (in this case by DC-3) and to fly back to Rio in the *Caravelle*, thus having an opportunity of sampling its comfort and noiselessness.

The *Caravelle's* arrival in Rio caused something of a sensation. After flying over Galeao airport, it gave a low-level demonstration over the city, at the unanimous request of its passengers, and then

In Carasco, Montevideo.

Maiquetia, Caracas.





The *Caravelle* flew from Los Angeles to San Francisco International Airport in only 71 minutes.

went to show off its sleek lines to the crowds of Sunday bathers on Copacabana beach.

Demonstrations and inspection tours followed in quick succession, and each day the fame of the *Caravelle*, which was soon universally known as the "Magic Carpet", grew as more and more people experienced the pleasure of flying in it.

Popular enthusiasm reached its climax in Sao Paulo. No sooner had the *Caravelle* settled on the apron than it was besieged by dense crowds, which had to be dispersed by local police and firemen armed with water hoses before the passengers could disembark.

The rest of the programme in South America was completed without the slightest hitch. The *Caravelle* took off and landed so punctually that it proved capable of offering the same regularity of service as the best of today's scheduled airliners.

The technical incidents occurring during this first part of the tour were so few that they can be recorded in full:

- On arrival at Montevideo one of the main undercarriage tyres burst during the taxi run. This incident enabled Sud-Aviation to demonstrate how easy the *Caravelle* is to service, since the wheel was changed in less than twenty minutes, with the equipment carried aboard the aircraft,and take-off was made, as scheduled,an hour later.
- On the second trip to Rio a fuel regulator had to be changed in one of the jets.
- The only incident which necessitated a modification to the programme took place as the *Caravelle* was due to leave Caracas for Miami. The batteries, which had suffered from the strain placed upon them since departure from Paris (they had been used for engine starting at all points of call, and flights had been relatively short) refused to deliver enough power to start the jets. The whole set of batteries was replaced, and take-off was made after a delay of fifteen minutes.

Before passing on to a description of the second part of the tour, I should like to pay a small tribute to the Rolls-Royce engines installed in the *Caravelle*. It was not until the second visit to Rio, after the Buenos Aires–Rio stage and after 25 hours of flying, that the oil tanks for the jets had to be topped up for the first time since leaving Paris. And the amount of oil required was just over ¾ of a pint per engine!

North America

After a highly successful tour of South America, the *Caravelle* crew left Caracas on May 2nd, 1957 for Miami and New York.

The Captain's Impressions

How I Piloted the Caravelle

By Lionel Casse

When Sud-Aviation decided to send the *Caravelle* on a tour of the Americas, Georges Héreil, the company's President and Managing Director, placed me in charge of the operation. On the trip, the like of which had never before been made by a prototype, I was assisted by a specially selected crew made up as follows:

André Lesieur, Air France captain on the North Atlantic routes and a former member of the Lafayette Squadron.

Jacques Vergine, Air France engineer officer and former member of the Lorraine Wing, whose good humour never failed and was of inestimable value to us throughout the long tour.

During the flights across the North and South Atlantic, navigation was in the hands of Paul Comet. What better compliment can I pay him than to say that he was true to himself?

All of us had flown the *Comet* when it was in service with Air France. The operating methods used on these earlier flights had been extremely cumbersome and, in my opinion, quite unsuited to high-speed aircraft. I had discussed this matter with André Chaume, at that time Chief Pilot of the *Comet* fleet, and we were about to work out simpler operating procedures when the *Comet* was finally grounded.

I returned to the problem as soon as I was told about the *Caravelle* trip. On such a tour, which included flights on very congested airways and approaches to airports with a high traffic density, I decided that it would be out of the question to use the same operating methods as for the *Super Constellation*. What is more, our routes and most of the airports we were to use were completely unfamiliar to us.

I therefore came to the conclusion that all we should need for actual "en route" navigation would be one schedule from which we could at any time determine our position in relation to the radio facilities along the route, our estimated times of arrival over these points and at our destination, and our remaining fuel supplies. The schedule should also contain the call signs and frequencies of the various radio aids, so that the pilots would need no other equipment, not even a computer.

At the *Caravelle*'s high operating altitudes surprises are the rule, since changes in the wind are both frequent and sudden. Wind speed is normally anywhere between 60 and 100 knots.

Paul Comet designed this schedule for us, and it proved entirely satisfactory throughout the 32 overland stages of our tour.

The many members of the U.S. Civil Aeronautics Administration who flew with us in the flight station were surprised to see that we had nothing to do—at any rate apparently. But each stage was very carefully prepared beforehand; both Lesieur and I knew, before we set off, exactly what we were going to do.

The traditional crew, armed with a computer, consulting numerous documents and making constant written entries, as is the rule in conventional aircraft, is quite out-dated in an aircraft which covers from 6 to 8 nautical miles per minute.

We not only introduced simplifications in "en route" operating procedure, but also applied the same principles to stacking, approach and landing. Careful utilization of the aircraft's qualities made it unnecessary to change the jet regulation on arriving over a radio aid. In my view, the theory held by some pilots that a constant indicated speed should be maintained, and the engine performance changed accordingly, is incorrect. On a new aircraft equipped with air brakes, new procedures, made possible by these devices, must be applied. I therefore gave considerable thought during the tour to how the best use can be made of the air brakes during a landing approach.

Finally, I arrived at a clear picture of the ideal composition of the crew for a high-speed aircraft. Such a crew will always be smaller than for a conventional aircraft, as flying times are shorter and the work simpler . . . that is, provided operating procedures are drastically modified.

Fundamentally, what does an airline expect of its crews? That each flight be made in the shortest possible time, at the highest level of safety and comfort, and . . . at the lowest cost.

These aims can be achieved with the *Caravelle* by a crew which realizes that the aircraft's speed and performance bring not extra work or hopeless complications, but greatly increased flexibility in operation through the use of entirely new methods.

Air France Captain Lionel Casse and President G. Héreil.

A Passenger's Impressions

"It's the Scenery that Moves"

By Georges Février, INTERAVIA-France

I have had several opportunities of flying in the *Caravelle* since it made its first flight a bare two years ago. Some of these trips were even made in the first prototype when it was still fitted with its original test equipment.

However, when Georges Héreil suggested I went along on some of the *Caravelle*'s American flights, I had no hesitation in accepting his invitation. An inveterate air traveller, with more than 5,000 hours as passenger aboard almost every type of aircraft, I took this as an excellent opportunity of getting to know the French twin-jet transport under real operating conditions.

I made three flights in the SE.210 in the United States—from New York to Washington, Washington to Atlanta, and Atlanta to Miami—and rediscovered in magnified form the same unusual sensations I had experienced in the first prototype—the second prototype's decoration and sound-proofing are unequalled.

As soon as the aircraft reaches its take-off speed, it climbs like a fighter. A few minutes later, at cruising altitude, the enchantment begins: not a sound but the soft music from the loudspeakers, not a movement or a vibration; the passenger has the extraordinary feeling of being suspended in a drawing room, with the scenery, like a theatre backcloth, moving beneath him. From time to time he becomes vaguely aware of a slight tremor in the wings, and it takes the noise of the air in the brakes during a rapid descent (a noise which the public address system warns him to expect) to remind him that he was not stationary on the ground.

The *Caravelle* fitted with astonishing ease into the dense and varied traffic patterns at Idlewild, Washington and Miami (on one occasion we followed an *Apache* down, on another a *Viscount*). Thanks to its excellent brake system, it used only half the runway on each occasion.

At Miami I asked Dick Merrill, Eastern Airlines chief pilot (aged 61, with 30,000 flying hours to his credit), what his impressions of his flight in the *Caravelle* were: "I didn't think it was possible," he replied, "it's a revelation!"

Both revelation and revolution. With twice the speed of conventional aircraft and with the high level of comfort it offers (silence, perfect pressurization and absence of vibration), the *Caravelle* opens a new age in air transport, an age which we all hope will soon be with us.

One warning, however: once you have flown in this aircraft, you will have difficulty in getting used to conventional aircraft again.

In Montreal, the world's air transport capital the crew first heard their mother tongue again, though with a different accent.

Its arrival at Idlewild was an event of major importance in view of the Port of New York Authority's unyielding attitude on the subject of noise. Hitherto no jet aircraft, neither the *Comet* nor the Boeing 707, had ever been allowed to land at Idlewild for this reason. However, a series of noise measurements had been made at Orly between March 18th and 23rd by a Port of New York Authority team and had revealed that the *Caravelle* is less noisy than the heavy four-engine aircraft regularly operating on commercial services. A provisional and very limited authorization was therefore granted just before the aircraft's departure from Paris for it to use Idlewild for demonstrations. We were all aware that a great many people would follow the *Caravelle's* demonstrations very attentively, and that their opinion would have considerable weight when the Port Authority made its final decision.

Once again the *Caravelle* proved that it is ready for regular operations without restrictions, since, after seven demonstrations flights, all the experts presented favourable reports, and the local inhabitants, though very "touchy" on the subject of aircraft noise, had raised no complaints.

This initial success augured well for the future, and the *Caravelle* crew set off on the remainder of its North American tour full of confidence. Though its reception was perhaps not so overwhelming as in South America, a warm welcome was shown to the new aircraft from France wherever it went.

The *Caravelle* received many visitors. In North America alone, more than 2,000 guests, including official personalities, airline managers and engineers, aircraft manufacturers, airline crews and reporters, were given an opportunity of assessing its flying qualities, and made no secret of their admiration and interest. Far too many compliments were made to be quoted in full here, and they were paid by too many well-known persons for only a few to be selected. Coming as they did from men whose knowledge and experience are recognized throughout the world, they were naturally highly gratifying to the Sud-Aviation management.

On the operational level, the *Caravelle's* visit to the United States proved that this aircraft can fit without the slightest difficulty into the world's densest, most closely controlled and most congested air transport network. On each of its flights the *Caravelle's* crew was accompanied in the flight station by a Civil Aeronautics Administration official who went along for two reasons: firstly to provide valuable assistance through his detailed knowledge of the traffic rules in each area, and secondly to gather practical information on a problem which is causing American aeronautical authorities the gravest concern, namely the integration of jet aircraft into the present traffic pattern.

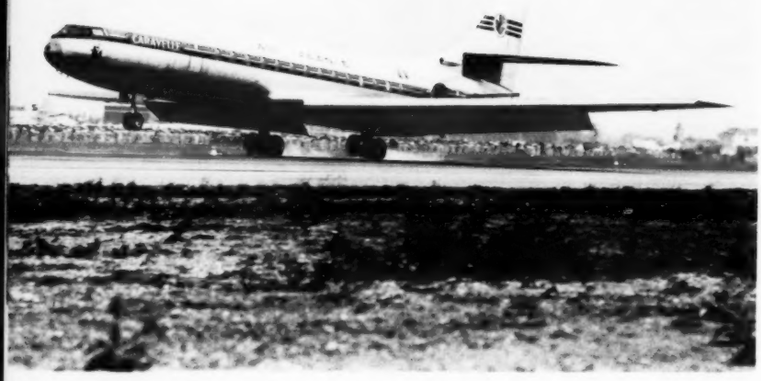
Within its North American programme the *Caravelle* was demonstrated to 32 U. S. airlines, receiving wherever it went the most flattering comments on its punctuality and regularity. During its 54 days in the United States there was only one incident worthy of mention: the fracture of a brake tube at Dallas, which took half-an-hour to repair.

The *Caravelle* returned to Idlewild on June 18th and triumphantly left the United States on June 20th to pay a friendly visit to Canada. Calls were made at Toronto and Montreal, where the crew were delighted to hear their mother tongue again and where the aircraft was demonstrated to the permanent members of the I.A.T.A. and I.C.A.O. delegations.

The return flight

Finally, on June 23rd, for the first time for many weeks, the crew found themselves alone aboard the aircraft on the first stage of the return flight, Montreal to Gander. After a day's well-earned rest in the invigorating Newfoundland air, the *Caravelle* left the American

continent on June 25th. The tanks had been filled to capacity, and the wings carried 33,500 lbs. of fuel, enough to cover the 2,537 miles to Paris non-stop. Six hours and sixteen minutes later, with 6,600 lbs. of fuel still left in its tanks, the *Caravelle* touched down at Orly airport, after an absence of 68 days. It was welcomed by representatives of France's entire aviation world, all come to salute the French aircraft industry's most eloquent ambassador.



Home again . . . landing at Paris-Orly.

The "*Caravelle* family": (left to right) Mme G. Héreil, Air France hostess Geneviève Salzani, Pierre Nadot (Chief of Flight Test, Sud-Aviation), Lionel Casse (Air France captain), President G. Héreil, André Lesieur (Air France), Jacques Vergine (Air France), Robert Blanchet (author of the present report), M. Lacombe. In the rear, Air France Chief Navigator Paul Comet and Chief Engineer Pierre Satre (Sud-Aviation).

After the success of the *Caravelle's* American tour, Sud-Aviation President Georges Héreil has every justification for his "Napoleonic pose."

Technical details of the tour

Caravelle Prototype No. 02 F-BHHI

The aircraft used for the demonstration tour had a gross weight of 90,200 lbs. and on leaving Paris had logged roughly 200 flying hours. (It may be mentioned in passing that by this time the first prototype had already exceeded 1,000 hours).

The jet engines fitted are two Rolls-Royce *Avon RA.26s*, each delivering 10,000 lbs. of thrust. From 1958 onwards, however, production aircraft will be powered by RA.29 jets, whose thrust of 10,500 lbs. will be raised to 11,700 lbs. in 1960. The performance of the production aircraft will of course be improved by this increase in thrust; for example, average cruising speed, 400 knots in the present aircraft, will rise to 430 knots.

The cabin of the demonstration aircraft was equipped to carry 52 passengers in a first class layout with seats four abreast. Two rows of seats facing each other and separated by a table formed a special lounge for V.I.P. guests at the front of the cabin. Two additional windows on each side will be added in the production models, which will be able to carry 64 passengers on first class services or 80 passengers on tourist routes.

During its tour of the Americas the *Caravelle*'s freight holds carried a load of 5,500 lbs. of spares and tools.

Organization of the flights and performance recorded

The policy followed in working out flight plans was not so much to obtain record performance as to demonstrate the *Caravelle*'s qualities under normal commercial operating conditions, that is, by selecting the best possible compromise between performance, economy and passenger comfort.

The demonstration flights, which lasted an average of 45 minutes in South America and one hour in North America, normally comprised a climb to about 20,000 ft., followed by a cruise during which refreshments were served and passengers were given technical information about the *Caravelle* over the loudspeakers, together with details regarding the particular flight (take-off weight, time of climb, speed etc.). The commentary also enabled the passengers to appreciate the quality of the sound relay system, which all admired for its transmission of both the spoken word and music.

The flight ended with a descent at 4,000—6,000 ft./min., using the air brakes, and by a landing in which the two captains, who took turns as first pilot, vied with each other in skill to such an extent that one day the C.A.A. controller taking part in the flight took up the microphone at the end of the taxi run and told the passengers: "In case you haven't noticed it, we are now on the ground".

For city-to-city flights the cruising procedure varied according to the stage length, and passengers were given additional information on the route followed and interesting landmarks. After landing, the performance recorded was also announced.

By way of conclusion, the table below gives a brief insight into the complexity of the programme and the detailed planning required to ensure its success.

	Number of stages	Number of demonstration flights	Total number of flights	Number of take-offs and landings	Total consumption in kg	Hours of flight-city-to-city	Total hours of flight	Distance covered (km)	Number of guests on flights
South America	11	17	28	56	122,050	37 : 09	51 : 18	21,255	758
United States	18	42	60	120	179,674	35 : 17	80 : 13	19,304	2,008
Canada	4	1	5	10	17,948	5 : 57	6 : 57	3,658	158
North Atlantic crossing	1	0	1	2	12,720	6 : 26	6 : 26	4,093	0
Total	34	60	94	188	332,392	84 : 49	144 : 54	48,310	2,924

Visit to Cascina Costa

The small village which bears this name is difficult to find by road—even if one knows that it lies at the southern corner of Lombardy's main airport, Milano-Malpensa. However, after taking a few wrong turnings, *Interavia's* reporters finally succeeded in finding their way from Gallarate to Samarate and thence along a deserted country road . . .until they suddenly found their car's nose up against a factory gate, bearing the name "*Costruzioni Aeronautiche Giovanni Agusta*"; they had arrived.

Cascina Costa has been a familiar name to aviation historians ever since *Giovanni Agusta* settled there. As early as 1909 Agusta was working on his first unpowered biplane, which he himself demonstrated in Capua in 1910, using a motor car for towing. In 1911 he designed and made a parachute, then joined Gianni Caproni, but finally set up on his own as designer and manufacturer of gliders with auxiliary engines.

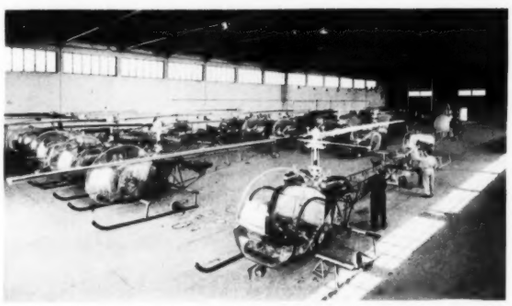
Today Giovanni Agusta's four sons are continuing his work, and most active at Cascina Costa are *Commendatore Domenico Agusta* (General Manager) and *Dr. Mario Agusta* (head of the Divisione Aviazione). They are assisted by *Engineer Filippo Zappata,* who was for many years chief designer with Blériot, Cantieri Riuniti dell'Adriatico and Breda. The company at present employs roughly 1,300 persons, the majority of whom, however, work at the Verghera engineering plant (Meccanica Verghera Agusta), where up to 150 motor-cycles (175 or 125 cc) are produced daily.

With their background experience in the mass production of machined parts and their decades of aviation tradition, the Agusta brothers decided to take up *helicopter construction* in the early fifties and concluded an agreement with Bell Aircraft Corporation to manufacture the Type 47 under licence. The first Agusta-Bell helicopter (Type 47G) flew on May 22nd, 1954, and since that date more than 200 helicopters of the Types 47G (200 h.p. Franklin 6V4), 47 G-2 and 47J (both with 260 h.p. Lycoming VO-435 engine) have been delivered to customers in Italy and abroad.

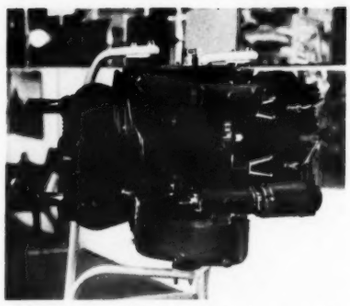
What particularly impresses the visitor are the methods of precision woodworking used in the construction of the *rotor blades.* The difference in weight between the two blades for the Bell 47 (roughly 95 lbs. each) may not exceed *two grammes,* and each blade must in addition be dynamically balanced with the utmost precision. As the blades have to be shaped from laminated blocks—a sandwich consisting of birch, spruce and balsa—each individual birch, spruce or balsa layer is cut into two halves before bonding, half being used for each of the blades. The finished blades then have holes drilled in them to reduce weight, are covered with a film-like fibreglass fabric and fitted with stainless steel leading edge protecting plates; fittings for attachment to the rotor hub are glued in place and finally secured by screws.

The actual machining of the transmission parts is done by conventional methods, though with extremely high precision standards. The shops contain the usual milling machines, lathes and boring machines, and use the normal setting up methods. Finally there is an efficient work preparation section. Final assembly presents no special complications, and the only surprise to the visitor is the very small space required for the helicopter assembly line and the short assembly times. At present Agusta is producing roughly 15 per month in a relatively small area.

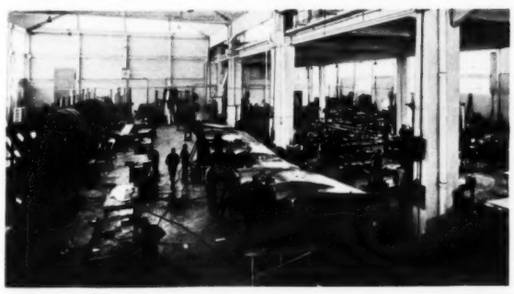
The report on this visit would be incomplete without mention of the attractive *AZ.8L four-engine feeder airliner,* which has been developed from A to Z—from Agusta to Zappata—at Cascina Costa. Designed for 22 or 26 passengers and fitted with four 550 h.p. Alvis *Leonides 502* engines, the all-metal aircraft is intended as a DC-3 replacement for the less wealthy airlines. *Main advantages:* low cost price ($300,000 to $350,000) and low operating costs, rugged construction, ability to use small grass airfields. *Main technical data:* span 83.5 ft., wing area 620 sq.ft., weight equipped 15,650 lbs., gross weight 23,810 lbs., cruising speed at 10,000 ft. and with 57.5% of take-off power 200 knots, stage length up to 1,600 nautical miles.—The first flight can be expected to take place shortly.



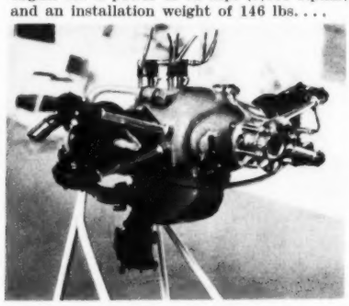
Assembling the Agusta-Bell 47 G-2 (three-seat) and 47J (four-seat) helicopters.



Agusta has also recently begun to build aircraft engines, the GA.70 V helicopter engine for a power of 72 h.p. (3,100 r.p.m.) and an installation weight of 146 lbs. . . .



The wing centre section of the Agusta-Zappata AZ.8L all-metal feeder airliner (four Alvis *Leonides 502s*), for 22 to 26 passengers, spans roughly 42 ft.

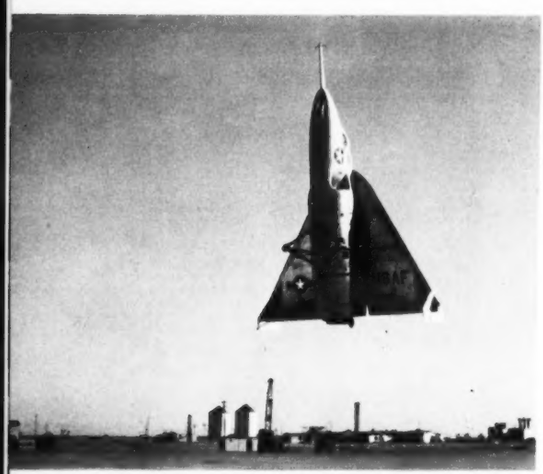


. . . and the GA.40 sports aircraft engine with a power of 42 h.p. (2,700 r.p.m.) and a weight of 86 lbs. Both engines were exhibited at the Paris Show.

Helicopter view of the Cascina Costa plant. The firm's engineering plant (Meccanica Verghera Agusta) is in the neighbouring small town of Verghera.

During climb, control is provided solely by regulation of the engine thrust, deflection of the exhaust stream and operation of small jet nozzles at the wing tips.

The Ryan X-13



The aircraft has separated from the rig and is preparing for vertical climb. During this manoeuvre the pilot receives appropriate signals from an assistant at the top of the rig. The assistant apparently also controls the supporting trapeze.

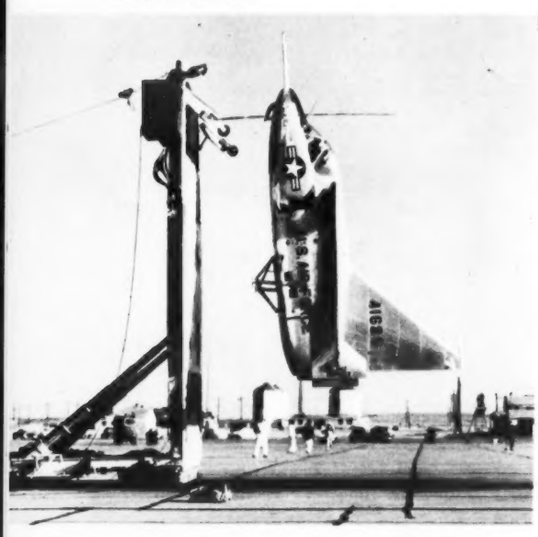
For the past 20 months the Ryan X-13 experimental no-undercarriage VTOL aircraft has been undergoing a systematic flight testing at Edwards Air Force Base, California, to the full satisfaction of both manufacturers and military authorities. After a large number of vertical take-offs and landings, the first transition to level flight, followed by a return to the vertical position for landing, was made on April 11th this year.—Fitted with a Rolls-Royce *Avon* jet (thrust class 10,000 lbs.), the aircraft is stabilized and steered solely by jet control during the jet-supported portion of its flight, and is controlled with the aid of its aerodynamic surfaces only during level flight.

Unlike the other "tail sitters" hitherto revealed (Lockheed XFV-1, Convair XFY-1 and *Atar Volant*), the X-13 takes off from a mobile, tilting rig which also serves as maintenance rig and transport vehicle. The aircraft is attached to the rig by means of a hook under its nose and is braced by tubular struts in the region of its centre of gravity. As it is tilted into the vertical position a trapeze-like supporting framework for the hook swings out from the top of the rig, so that immediately before take-off the X-13 hangs vertically in the air some distance from the rig, supported solely by the hook. After opening the power lever the pilot can immediately begin his vertical climb without operating the control surfaces.

Landing, of course, is carried out in the reverse order. The aircraft descends slowly, supported on its jet exhaust, and engages its nose hook in the cable of the rig's trapeze, whereupon all that remains to do is to throttle down the engine.

Ryan has recently been reported to be working on a number of other projects for supersonic VTOL fighters and fighter bombers financed by the U. S. Air Force and U. S. Navy.

The X-13 (length roughly 24 ft., span roughly 21 ft.) is suspended from a cable and rests on supporting struts on the rig. The pilot's seat tilts forward for vertical take-off and landing.



The Bell X-14

A fundamentally different approach to the solution of the VTOL problem has been adopted by Bell in the design of its X-14 experimental vertical take-off aircraft for the U. S. Air Force. Unlike the X-13, Bell's aircraft, which is fitted with two Armstrong Siddeley *Viper* jets, takes off vertically in a horizontal attitude. The necessary lifting thrust is produced by deflecting the exhaust of both engines downwards. For hovering and low-speed flight, control about all three axes is provided by compressed air nozzles at the wing tips and the rear of the fuselage. To judge by the take-off thrust of the engines used, the weight of the aircraft cannot be more than about 3,300 lbs. Length is 25 ft. and span 34 ft.—Development began in July 1955, and first hovering tests were made in February 1957.

Bell test pilot David W. Howe is in charge of the X-14's flight testing.

The aircraft takes off vertically and is controlled about its three axes by small jet nozzles at the wing tips and in the rear of the fuselage.

The Bell X-14's nose carries – side by side – two Armstrong Siddeley *Viper* jets whose exhaust stream can be deflected downwards for take-off and landing.

As soon as the engines have reached full rev. speed, the pilot switches on the jet deviation device.

What's in the Air?

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AIR TRANSPORTATION

● **Scandinavian Airlines System** has placed a firm order with Sud-Aviation for six SE.210 *Caravelle* jet aircraft at a total cost of 90,000,000 Swedish kronor, for delivery in January, February, March, April, September and October 1959. The company has also taken an option on a further 19 *Caravelles*, for possible delivery between 1960 and 1963.—S.A.S. plans to operate only jet aircraft on its medium and long stages by 1965, according to a report from Copenhagen. The new procurement programme covers six Douglas DC-8s and ten Convair *Metropolitans*, in addition to the above-mentioned 25 *Caravelles*. All services to Paris, London and the Middle East will be operated by *Caravelles* from 1959 onwards, while the DC-8s will be used on the intercontinental routes from 1960 onwards. The *Metropolitans* are destined primarily for minor routes. The total cost of the programme will amount to roughly 500,000,000 Danish kroner.

● **British European Airways** has stated that it is considering the purchase of *Comet 4Bs*. It is understood that the Corporation is likely to have half a dozen *Comets* to meet competition from S.A.S. and Air France with their *Caravelles* in 1959. This will affect the B.E.A. medium jet specification, inasmuch as it will mean deliveries of the 70—80 seater 600 m.p.h. type will be delayed until about 1964. A. V. Roe, de Havilland and Bristol are still the three firms competing for this order.

● **The Czechoslovak airline C.S.A.** is planning to open a direct non-stop air service between Prague and Cairo with Soviet-built Tu-104A jet transports. The aircraft will cover the distance in 3 hours 40 minutes, a saving of about four hours over the present round-about flight via Vienna and Rome.—The Tu-104A is an improved model of the Tu-104, which is now making daily flights between Moscow and Prague and thrice weekly flights to Peking. The new model carries 70 passengers and is lighter in weight and has a longer range than its predecessor. It flies at an altitude of 30,000 ft., with a cruising speed of 430 knots. Crew: two pilots, one engineer, one navigator, one radio operator, three hostesses.

● **Prague Airport** is to be expanded into an international air transport centre for traffic from West and North Europe to the Middle and Far East. Plans include not only the lengthening of the runways, but also construction of a large terminal building. Bratislava Airport is to be enlarged to serve as alternative to Prague for jet aircraft.

● **Royal Air Maroc** is the new name adopted on July 1st by the former Compagnie Chérifienne de Transport Aérien Air Atlas/Air Maroc.

● **The Port of New York Authority** on July 10th opened the sale of $28,000,000 of revenue bonds to finance improvements at La Guardia and Idlewild Airports.

● **The Los Angeles Airport Commission** has set the latter half of 1959 as target date for completion of the Los Angeles International Airport development project, which includes construction of a 10,000-ft. runway.

INDUSTRY

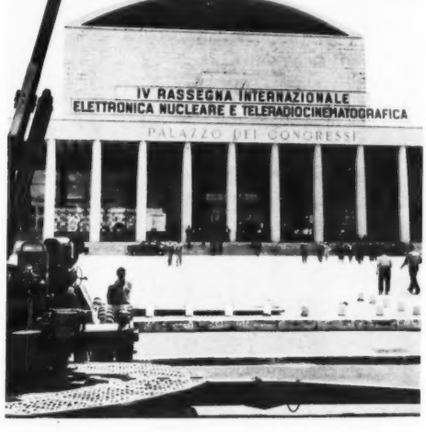
● **Lockheed Aircraft Corporation** may purchase an electronic company to acquire additional "competence" in this field, though it has no negotiations actually under way at the present time. Board Chairman Robert E. Gross points out that 25% of aircraft costs already go for electronics, and as much as 50% of missile costs may be in electronic components.—The company's order backlog is now $1,400,000,000. Guided missile business will approximate $75,000,000 in 1957 and is expected to double in the next two years. Speaking of the civil market, Gross said he expects sales of *Super Constellations* to continue at about two a month for the rest of 1957. Orders for 136 *Electra* turboprop airliners have been received so far. In the military field, Gross said that Lockheed plans to fly the prototype of a jet-powered military utility transport and training aircraft on September 4th of this year. He added that the aircraft also has commercial possibilities.

● **Northrop Aircraft Inc.** announces a U.S. Air Force order, valued at $73,000,000, for production of the SM-62 *Snark* intercontinental guided missile. The *Snarks* are to be delivered to the Strategic Air Command. This is the first *Snark* production contract let by the Air Force, although prototype versions of the missile have been manufactured by Northrop for testing purposes.

● **General Electric Company's** Missile and Ordnance Systems Department has received a $158,000,000

Air France's flight simulator for the Lockheed L-1049 *Super Constellation*. Overall view (left) and pilot's cockpit (right).

The 4th International Electronics and Nuclear Energy Exhibition was held in Rome from June 22nd to July 7th. Left, the entrance to one of the three exhibition buildings. Centre, official visit by the President, Giovanni Gronchi (foreground, second from left with glasses). Other prominent guests: Professor Focaccia, Chairman of Italy's National Committee for Nuclear Research (back to camera); Finance Minister Gava (centre with glasses); Professor Medi, Director of the Geophysical Institute, University of Rome (talking to President Gronchi); President Castracane, Chairman of the Exhibition Committee (foreground, right). Right: Senator Giuseppe Caron, Under-Secretary for Civil Aviation, Ministry of Defence (left) in conversation with Giorgio Lourier, Interavia Manager, Rome.



E. G. Uhl, Vice-President of the Martin Company, officially hands over the 1,000th *Matador* surface-to-surface guided missile to Lieutenant Colonel Allen Warefield, Jr., U.S. Air Force.

De Havilland *Comet 3* demonstration tour of Europe. Picture shows the aircraft at Helsinki Airport. In the foreground, an Aeroflot Ilyushin Il-14.

The Fédération Aéronautique Internationale's Annual Meeting in Palermo (June 25th to 30th).

Aquila Airways is operating an experimental service between Southampton and Montreux this summer, using *Solent* flying boats. Picture shows the *Solent* after alighting on Lake Geneva.

contract for development work on the nose cone for the Air Force Ballistic Missiles Programme. Specifically, the contract entails work to be performed on the nose cone for the *Atlas* I.C.B.M. and the *Thor* I.R.B.M.—The Research and Advanced Development Division of *Avco Manufacturing Corporation* also announces receipt of a $110,000,000 U.S. Air Force contract for the nose of the *Titan* I.C.B.M.

● **More than 2,000 commercial transports** have been built and delivered for use by American and world airlines since the end of World War II, according to figures published by the Aircraft Industries Association of America. These aircraft, not counting spare engines and parts, are valued at approximately $2,000,000,000. The total includes more than 700 twin-engine transports and at least 1,300 four-engine airliners. America's transport manufacturers, according to A.I.A., are still scheduled to deliver 400 piston-engine transports to U.S. and foreign carriers. Beginning in 1958, air carriers throughout the world will start taking delivery of a minimum of 200 turboprop and at least 320 pure jet transports.

● **The Netherlands Nationaal Luchtvaartlaboratorium** handled a total of 31 research projects during 1956, while the Netherlands Aircraft Development Board (Instituut voor Vliegtuigontwikkeling) concentrated most of its efforts on development of the Fokker F.27, the Nederlandse Helicopter Industrie H-3 ramjet helicopter and the Aviolanda AT-21 target drone. The *Friendship* is at present undergoing official tests for the Netherlands Certificate of Airworthiness and the United States type certificate. The N.H.I. project involves construction and development of three type H-3 helicopters. Aviolanda is to get a total of 1,000,000 guilders for development of the AT-21. The remaining costs—300,000 guilders—will be borne by the firm itself.

● **Hispano Aviación** plans the licence production of some 40 Dornier Do 27 communications aircraft in Spain.

AIRCRAFT AND POWER PLANTS

● Construction of a *four engine commercial transport*, designed in particular for domestic operation, is to begin shortly in Poland. The aircraft, designed by Polish engineers, bears the designation *MD.12*, is fitted with 340 h.p. WN-3 engines and is reportedly to have accommodation for 20 passengers. The *MD.12* is said to feature short take-off and landing distances.

● A more than 40% increase in payload has been announced for the *Bell 47J helicopter*, made possible by a C.A.A.-approved increase in gross weight from 2,565 lbs. to 2,800 lbs. The 47J is fitted with a Lycoming V0-435 engine (260 h.p. for fixed-wing aircraft) hitherto derated to 220 h.p., now certificated for operation at 240 h.p. take-off rating.

● Without being removed from the test bed, the *Napier Gazelle* free-turbine engine recently completed three unofficial 150-hour cyclic runs, based on the new Ministry of Supply type test schedule, which

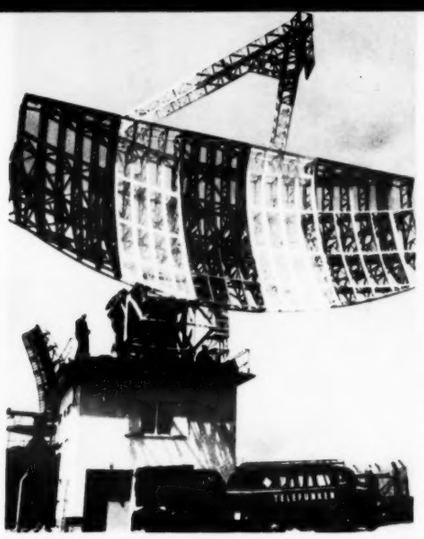
New Chairman of Fairey Aviation Co. Ltd. is Geoffrey W. Hall, half-brother of Sir Richard Fairey, who died last autumn.

Appointments at Fairey Aviation: Group Captain Gordon Slade (left) to Superintendent of Flying, Peter Twiss (right) to Chief Test Pilot.

Group Captain John Alexander Kent, formerly Chief Test Pilot at the Royal Aircraft Establishment, Farnborough, has joined Kelvin Hughes (Aviation) Ltd., as Sales Manager.

August Euler, German aviation pioneer and Secretary of State for Air after World War I, died on July 1st, at the age of 89.

Sud-Aviation's *Baroudeur* again figures on the short list from which N.A.T.O. will select its ground attack aircraft. It was recently test flown by Major Arthur Murray, member of the Mutual Weapons Development Team.



Telefunken GmbH is building three giant radar installations (range up to 300 miles) for the Munich, Frankfurt and Hanover air traffic control regions.

Baron Hervé de Gruben, Belgian Ambassador to Bonn (right), was Sabena's 100,000th helicopter passenger. Left, Managing Director Willem Deswarte.

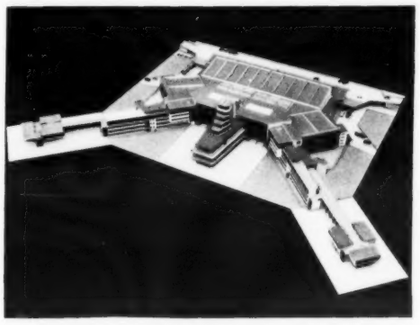
includes 50 hours of the engine's maximum performance rating and 300 accelerations. During the three 150-hr. runs, the *Gazelle* did 150 hours at full power and 900 accelerations. The engine has a max. output of 1,450 s.h.p. and is of the same type as that which powers the Westland *Wessex* Navy helicopter. *Gazelles* will also shortly be installed in the prototype of the twin-engined Bristol 192.

● The prototype of the Spanish *ENMASA Sirio S-3* 7-cylinder radial engine (version with the 500 CV S-2's reduction gear) has made its first bench runs. ENMASA has also been making improvements to the S-2 with a view to raising performance above 500 CV. The company also reports a speed-up in development of the *Alcion A-1* prototype (7-cylinder radial of 275 CV) as well as the endurance tests on the *Beta B-4* nine-cylinder radial (775 CV).

● The *Chance Vought F8U-3*, successor to the F8U-1 *Crusader*, is to be fitted with a P & W J75 jet with afterburner; total thrust 15,000 lbs. The F8U-3 is to have a top speed corresponding to Mach 2+. Flight tests are scheduled to begin in the summer of 1958 and first deliveries to the U.S. Navy in 1960.

● C.A.A. and A.R.B. representatives recently visited Armstrong Whitworth to discuss the validation of the *AW.650 Freightercoach* in the U.S.A. The manufacturers intend to obtain an American type certificate as early as possible, and a Type Board Meeting has discussed the conditions under which the A.R.B. Certificate of Airworthiness would be acceptable in the U.S.A. A full-scale mock-up of the AW.650 is nearing completion at Baginton.

● The prototype *Macchi MB.326* two-seat jet trainer is due to fly in late September or early October this year.



Model of a new passenger terminal for Frankfurt's Rhein-Main Airport, as shown at the Berlin International Building Exhibition. *(Photo: Flughafen AG., Frankfurt; Max Göllner.)*

In prototype form it will be powered by the Armstrong Siddeley *Viper ASV.8* of 1,750 lbs. static thrust, while the production model may use the *Viper ASV.10* of 2,000 lbs.

● The prototype of the *Yugoslav Ikarus fighter* is fitted with an Armstrong Siddeley *Viper ASV.8* jet engine, while the production version will have the Bristol *Orpheus*.

STRUCTURAL MATERIALS, ACCESSORIES

● A new *titanium alloy* is announced by RemCru Titanium Inc. Known as C-130 A Mo, it contains 6½% aluminium and 3¾% molybdenum.

● *Sylvania Electric Products Inc.*, Waltham, Mass., announces development of a new mobile electronic "combat computer" for solving military problems ranging from battle strategy and tactics to logistics for the U.S. Army. Called MOBIDIC (Mobile Digital Computer), it will fit into a standard-sized trailer.

● The new *SPQ-5 missile-guidance radar*, developed for the U.S. Navy by Sperry Gyroscope Co., Great Neck, N. Y., is now in service with the fleet for guidance of its *Terrier* missiles. So far, two cruisers, *Boston* and *Canberra*, have been converted into *Terrier*-equipped missile ships and carry the SPQ-5; the carriers *Topeka*, *Providence*, and *Springfield* now are being converted to carry the *Terrier*.

Lieutenant General Mario Porru Locci has been appointed Secretary General of Defence (Air), in succession to General Mario Pezzi who has reached retiring age.

A Lockheed F-104 *Starfighter* jet fighter testing its engine, complete with afterburner, at Edwards Air Force Base, California.

Société Industrielle d'Aviation Latécoère at the Toulouse Air Show. Exhibits, some of them models, were the Latécoère 258 *Malaface* (left half of picture, rear) and MS.20 missiles (left half of picture, front), as well as the wind tunnel model of the MS.20 (centre) and a booster for the MS.15 guided missile (right half of picture).

Aviation is Affected by Ninety Per Cent of the Programme

THE INTERNATIONAL GEOPHYSICAL YEAR

(July 1st, 1957 to December 31st, 1958)

It is not surprising that the daily press should have joyously welcomed the world-wide rocket fireworks which inaugurated the International Geophysical Year at the beginning of July. The public's imagination is naturally caught when the scientific *élite* from sixty countries unite in friendly rivalry to expand our knowledge of the earth to the outer limits of the atmosphere and beyond . . . perhaps pushing forward into extra-terrestrial space, which has hitherto been accessible only to the heroes of science fiction. Earth satellites. Arctic and Antarctic expeditions, deep sea soundings, earthquake and volcano investigations . . . in brief a programme to the taste of readers young and old.

But what has all this to do with aviation?

Very much more than might be supposed from a casual glance at the I.G.Y. programme. Of the twelve working groups set up by the C.S.A.G.I. (Comité Spécial de l'Année Géophysique Internationale), namely:

- Meteorology
- Geomagnetism
- Aurorae and airglow
- Ionosphere
- Solar activity
- Cosmic rays
- Longitudes and latitudes
- Climatology
- Oceanography
- Rockets and satellites
- Seismology
- Gravimetry

seven are concerned with questions of the utmost importance to aviation and space travel.

Professor Sydney Chapman (United Kingdom), President of the central I.G.Y. Committee, estimates that total costs for the 18-month I.G.Y. programme will exceed £100,000,000. Roughly speaking, about 90% of this total can be expected to provide either direct or indirect benefits to aviation.

A brief glance at the origins of the I.G.Y. will throw further light upon the aims of this international undertaking.

Fundamentally, the International Geophysical Year owes its existence to a shipwreck. In 1872-74 Austrian Naval Captain Karl Weyprecht and Polar explorer Julius von Payer made an expedition to the North Pole, during which they discovered Franz Josef Land, but lost their ship *Tegetthoff*, together with valuable scientific equipment. Weyprecht evidently had plenty of time for reflection during the long and dangerous return by sledge. At any rate he returned to Vienna convinced that sporadic expeditions and temporary scientific observation stations would never provide the systematic data required for serious research. At his instigation a number of International Polar Conferences were held, leading to the organization of the first International Polar Year from 1882-83, in which roughly a dozen countries and fourteen observation stations were involved. Fifty years later, in 1932-33, the second International Polar Year was held, with 46 countries participating. Under the original programme, the third Polar Year would not have been due until 1982. However, the well-known American geophysicist Lloyd V. Berkner argued that observation methods had improved so rapidly since 1932—particularly through the introduction of new electronic instruments—that it seemed justified to repeat the Polar Year after an interval of only 25 years. This opinion was supported by the International Council of Scientific Unions. At the same time it was decided that the name Polar Year was inadequate to describe the whole programme of investigations planned for all geographical latitudes. The International Council's meeting in October 1952 therefore chose the name *International Geophysical Year* for the undertaking that will unite leading scientists from every major country during the coming 18 months.

As even the briefest description of the activities of all twelve I.G.Y. committees would run into more space than is available here, the following limited number of questions of particular interest to aviation have been selected for mention. [1]

[1] Further information can be obtained from the following booklets: "The International Geophysical Year", by Werner Buedeler; published by UNESCO, Paris, 1957. — "Proposed United States Program for the IGY"; National Academy of Sciences, National Research Council, Washington, 1956. — A number of papers read by American geophysicists at a special meeting of the U.S. National Committee for the IGY (June 27th-29th, 1957); published by the National Academy of Sciences, Washington, 1957.

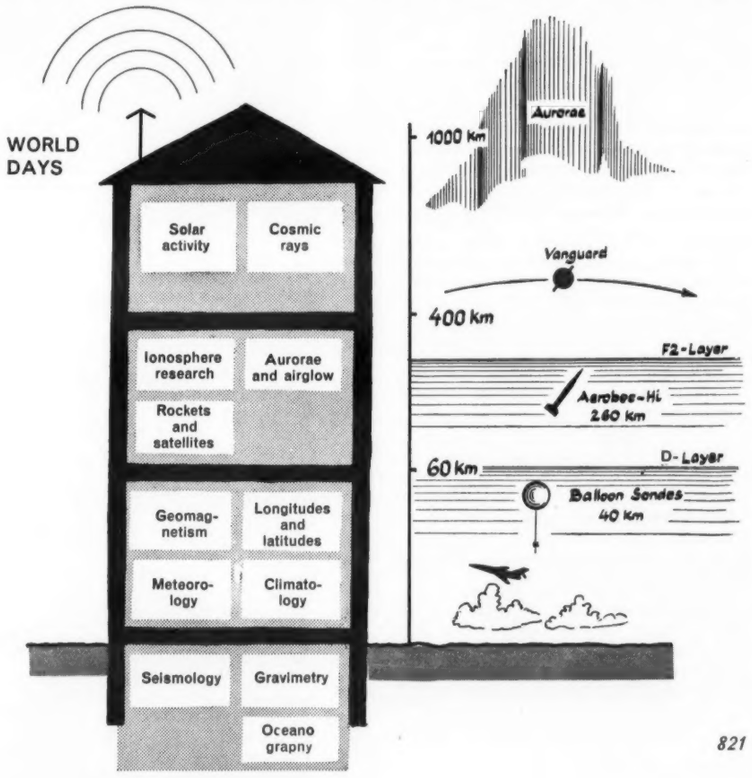
Meteorology

According to the report by the American expert Harry Wexler, published at the end of June 1957, 62 countries are participating in the I.G.Y.'s meteorological programme, i.e., in investigations of the layers of the atmosphere relatively close to the earth. More than 1,000 special observation centres have been set up throughout the world to reinforce the network of permanent meteorological stations.

In addition to normal ground observations, hundreds of stations will send up ballon-sondes to altitudes of 15 to 25 miles twice daily, to collect data on the composition and movement of the air in the stratosphere (barometric pressure, humidity, wind direction and speed, temperature, etc.). Rockets will be used to investigate the higher layers of the atmosphere up to altitudes of 80 or 100 miles. The value to aviation of this world-wide meteorological campaign is obvious.

"Using all of the interrelated data collected through the varied observational activities", states Professor Wexler, "it is expected that researchers will be able to throw more light on what are now mainly hidden answers to extremely significant problems of the atmosphere. Amongst these are the transmission of solar radiant

International Geophysical Year observations and comparative measurements will extend from the depths of the oceans to the ionosphere and exosphere. Whenever unusual circumstances, such as increased solar activity or protuberances, arise, a world-wide alert will be given; *World Days*, on which special extensive investigation is scheduled, have also been selected. The inside of the "I.G.Y. house" shows the activity of the twelve working groups distributed roughly according to altitude. In reality, of course, many of the domains overlap. Outside the house are some of the research aids for high altitudes.



energy, the albedo of the earth, motions in the atmosphere, the transport of energy and mass, causes of large-scale weather and climatic changes, etc."

All the meteorological stations will pass on their observations to three world data centres, in the United States, the U.S.S.R. and Geneva, Switzerland. Of particular value to aviation is the plan to prepare a daily weather map covering the entire globe. The United States has agreed to provide a daily sea level and upper air map for the Northern Hemisphere as its contribution to the effort. The U.S. Weather Bureau will use 169 stations during the I.G.Y. of which 118 are located in the continental United States, 18 in Alaska, 16 on Pacific Islands, 3 in Central America, 6 in the Antarctic and 2 at Arctic floating stations; in addition six weather ships (4 in the Atlantic and 2 in the Pacific) will also be making observations. Another 50 stations will be operated in conjunction with 21 countries in Europe, Asia, South America, Australia and Africa.

The most difficult problem arising, namely that of bringing up supplies for the Arctic and Antarctic stations, can today be regarded as solved. The Antarctic station known as " Little America " and six related stations working with the U.S. Navy and with foreign scientists have been in operation for many months. The Antarctic is gradually being changed from an uninhabited ice waste into a meeting point for international scientists and a broadcasting centre transmitting in all the world's major languages. Twelve countries have provided more than 6,000 operators for the 21 stations in the Antarctic; they are Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, United Kingdom, United States and U.S.S.R.

Though there may be a variety of economic and political interests concealed behind the pure scientific aims of the Antarctic programme, the atmosphere among the participating expeditions has so far been friendly. For example, Gordon Cartwright, Chief of the Observations and Station Facilities Division of the U.S. Weather Bureau, has been attached, since the end of 1956, to Russia's Antarctic Meteorological Centre at Mirny, at the edge of the ice pack. He describes his Russian colleagues as highly capable scientists and excellent companions.

In the Arctic, however, it has proved impossible to organize any such cooperation between the United States and Russia, as the region around the North Pole appears to be considerably " hotter ". On the other hand, there is close collaboration between the United States and Canada in this area.

In addition to meteorological observations in the narrower sense, the Polar Caps will be used for upper air research, investigations of aurorae, cosmic rays, etc., and this brings us, so to speak, up into the " second storey " of I.G.Y. research.

Ionosphere

Scientists apply the name " ionosphere " not to a clearly defined zone in space, but to several layers of electrically charged, low-density gases which stretch at altitudes of 45-250 miles (or 450 miles?) above the earth, and which are the home of so many phenomena affecting radio transmission and reception.

Although systematic observation of the ionosphere began decades ago and although the U.S. Bureau of Standards has for some time been issuing regular forecasts of " radio weather " for shipping and aviation, there are still many problems connected with the ionosphere that are entirely or partially unsolved.

It is generally known, for example, that the ionosphere reflects radio waves of certain frequencies but not others. Even the radio amateur knows that these reflections fail from time to time (fading) and that this and other radio disturbances are attributable to abnormal conditions in the ionosphere (stronger or weaker ionization). To discover the causes of these phenomena is one of the objects of the International Geophysical Year. Another problem awaiting solution is that of the extremely high temperatures in the ionosphere. The I.G.Y. is expected to provide new information on these and many other questions (aurorae, sun-spots, geomagnetic field, etc.), since thanks to a major increase in the number of radiosonde stations (from 10 in 1939 to 165 in 1957-58) it will, for the first time, be possible to carry out series of observations on a regional and global scale.

The U.S. Navy Research Laboratory carried out a high altitude separation test of an Earth Satellite launching vehicle at the U.S.A.F. Missile Test Center, Cape Canaveral, Florida, in May this year. The vehicle used was a modified *Viking* rocket.

German-American physicist Georg Hess making a last inspection of America's first earth satellite in a vacuum tank, at the U.S. Army Corps of Engineers' Fort Belvoir, Va., research centre.

The inauguration ceremony at Mirny, the Soviet Antarctic base . . . where guests include the Chief of the U.S. Weather Bureau's Observations and Station Facilities Division.

Rockets and satellites

America's *Vanguard* project for an earth satellite has already been discussed in detail on several occasions in *Interavia*, and all that need be added here is that a *Vanguard Computing Center* went into operation in Washington at the beginning of July. The Center, which is operated by International Business Machines Corporation on behalf of the U.S. Navy, will provide observation stations with accurate predictions of the satellite's trajectory.

According to the National Academy of Sciences' programme published a year ago, the United States plans to launch a total of 12 satellites and some six hundred research rockets, including the *Aerobee* (which will reach altitudes of 180 miles) and the two-stage *Nike-Deacon* rocket (95 miles).

Soviet Russia has announced that it will send out several satellites at the end of 1957 or beginning of 1958. Russian radio amateurs have been requested to keep in touch with the Electronics Institute of the Moscow Academy of Sciences, in order to obtain further details of the planned radio signals from the satellites.

France's contribution to the programme will be 12 *Véronique* research rockets, to be launched from the Sahara. The United Kingdom announces that a number of liquid-propellant rockets will be launched, and Japan promises the launching of Japanese-built solid-propellant rockets.

The aviation organizations' contribution

Yet another contribution to the I.G.Y. programme has been made by the International Civil Aviation Organization, on whose recommendation new radiosonde and radiowind meteorological stations will be taken into operation in South America and Southwest Africa to determine how far wind forecasts for aircraft en route can be improved by the use of such stations. The I.C.A.O. Council has selected five test routes (Panama-Lima, Lima-Santiago de Chile, Santiago-Buenos Aires, Buenos Aires-Rio de Janeiro, Leopoldville-Brazzaville-Johannesburg) and has chosen August 1st, 1957, to February 1st, 1958, as test period.

Finally, mention should be made of the assistance being provided by the U.S. Civil Aeronautics Administration, which has made its radio stations and teleprinter network throughout the world available for the transmission of important I.G.Y. information.

To sum up . . . mankind appears to be making tremendous efforts to perfect its knowledge of the globe. Whether the earth will be a better place to live in at the end of the International Geophysical Year, however, will not depend on the geophysicists alone . . .

International Congress of Aeronautical Sciences in Paris

by Jules Jarry, President of the Association Française des Ingénieurs et Techniciens de l'Aéronautique (A.F.I.T.A.)

The author Jules Jarry (left), President of the A.F.I.T.A. with Maurice Roy, Director General of the O.N.E.R.A. and member of the Académie des Sciences, at the opening session of the J.I.S.A.

During the 22nd International Air Show at Paris a Congress of Aeronautical Sciences was organized by the Office National d'Etudes et de Recherches Aéronautiques (O.N.E.R.A.), the Union Syndicale des Industries Aéronautiques (U.S.I.A.) and the Association Française des Ingénieurs et Techniciens de l'Aéronautique (A.F.I.T.A.) over the period May 27th-29th inclusive.

The programme was limited to four subjects:—

— inertial navigation
— interaction of internal and external flows in jet engines
— dynamics of flight
— axial turbojet aerodynamics.

Papers on 14 associated themes were read by specialists from the U.S.A., Great Britain, France and Italy to an audience of over 500 representatives of some 10 different countries.

● Inertial Navigation

Chairman : Professor Maurice Roy, Director General of O.N.E.R.A.

Lecturers : P. Schnerb, Chief Engineer of the Service Technique de l'Aéronautique (S.T.Aé), France:—" Some problems encountered in inertial navigation ".

Dr. W. Cawood, Director General of Scientific Research (Air), Ministry of Supply, U.K.:—" Some design problems of inertial equipment ".

P. Schnerb placed the greatest importance on the elimination of the effects of gravity in inertial navigation and underlined the two principles to be considered according to the method of accounting for gravity: The first presupposes the knowledge of the components of the gravity vector as a function of the calculated position so that, in the computor, they are subtracted from the measured accelerations. The second principle, which is especially useful for horizontal navigation of aircraft, eliminates gravity by measuring the two horizontal components of acceleration. The horizontal platform which is required by this principle can be established from the spatial system of reference if the curvature of equipotential surfaces is known—calculations are made by terrestrial coordinates and consider the motion relative to the earth, the Coriolis acceleration being subtracted.

The determining of the local vertical is a critical factor in inertial navigation. Levels or short-period pendulums are disturbed by accelerations but a theoretical solution is provided by a pendulum equal in length to the radius of the earth's curvature and with a period of 84 minutes. The vertical gyroscopes include a device which produces a very slow correction to any deviation from the vertical, but which cannot at the same time eliminate the effect of long-term accelerations and correct the setting of the gyroscope for the relevant local vertical. It is necessary to rotate the gyro system through an angle proportionate to the travel of the missile in space and equal to the angular displacement of the vertical.

Various possible solutions were examined and compared for error, and the speaker concluded that the different methods for defining the vertical from the gyro system seemed to be equivalent. Analysis showed that the error is made up of two components, one of which, increasing with time, is gyro drift; the second is the vertical error which oscillates through a period of 84 minutes.

*

Dr. W. Cawood's paper commenced with a brief description of the principles of inertial navigation followed by more detailed accounts of the principal components of such systems, namely gyroscopes, accelerometers, integrators, servos, etc. and gave a review of the special methods developed in the U.K. for testing precision gyroscopes and accelerometers.

The speaker compared the two main types of gyro (with one and two degrees of freedom) and underlined the advantage of the iso-elastic construction (same deflection of the centre of gravity of the gyro assembly for all directions of the applied acceleration). Three main types of accelerometer were examined, and reference was made to the performance required from them with special mention of the cross-coupling coefficient. Concerning integrators, the speaker noted a tendency to favour the electronic type, especially in the first integration stage, because of the initial lag of the tachogenerator type. The use of a gyro as a coupled accelerometer and integrator is an interesting development.

For gyros, the important quantity to be measured is the drift rate. Three main methods of measuring gyro drift were explained: the single axis platform test, the closed loop servo test and the open loop test. Accelerometers are tested either by altering the mass acted on by gravity, as in the added weight test, or by altering the magnitude of the effective acceleration as in the tilting test.

In conclusion the possible future of inertial navigation was discussed with particular reference to the use of mixed systems, where the long-term accuracy of e.g. astronavigation or Doppler navigation is coupled to the short-term precision of pure inertial navigational methods.

● Interaction of Internal and External Flows in Jet Engines

Chairman : Dr. Th. von Karman, Chairman of N.A.T.O.'s Advisory Group on Aeronautical Research and Development.

Lecturers : Carl F. Schueller, Chief Engineer of the National Advisory Committee for Aeronautics, N.A.C.A. (U.S.A.):—" Inlet-engine matching and control systems for supersonic airplanes ".

P. Carrière, Directeur scientifique de l'Aérodynamique à l'O.N.E.R.A.:—" Interaction of internal and external flows at the exhaust nozzle of a jet, at transonic and supersonic speeds ".

J. S. Alford, Designing Engineer, Jet Engine Department, G.E.C. (U.S.A.):—" Inlet flow distortion index ".

*

Carl F. Schueller discussed the complications in inlet design associated with operation at Mach numbers of the order from 2 to 4 and illustrated some of the techniques which could be used to match a supersonic inlet to a hypothetical turbojet engine. Using the example of a two-dimensional inlet operating over the Mach number range of 1 to 2, it was apparent that if the inlet is sized to operate near critical conditions for M=1, the corresponding inlet flow at M=2 is larger than the engine requires, and inlet-engine matching has to be achieved by some type of variable geometry inlet (translation of the compression surface, by-pass). If the inlet size is reduced to yield optimum performance at M=2, the inlet operation is super-critical at M=1, the inlet delivering less corrected air flow than the engine requires.

Relatively simple variable features may be possible for Mach numbers of 2 or less but at speeds significantly higher than Mach 2 there is a need for a more refined compression, and the cowl pressure drag becomes relatively more important. At M=4 for instance, an isentropic shape of the inlet may double the pressure recovery compared to the single cone inlet. The necessity for providing air spillage was emphasized, and it was shown that by-passed air must be discharged at an angle as near axial as is practical for each installation.

The next problem considered was the control of the variable geometry inlet. The speaker suggested that a good solution could be found by using a closed loop type control system; that is, a system where some parameter which is indicative of inlet operation is measured and compared to a corresponding fixed or scheduled parameter. The location of the normal shock is one of the critical inlet parameters, and by sensing the shock location and feeding this information into a control system the operation of the variable inlet can be optimized.

Schueller gave a block diagram of such a control system, and its operation was discussed, notably its dynamic behaviour because of the importance of the response time.

*

P. Carrière spoke on the practical and theoretical analysis methods and fundamental processes involved in the variations of effective nozzle thrusts, compared with theoretical maximum thrust when the conditions in external and internal flows vary respectively. By visualizing the flow it is possible to reveal the various aspects of interaction: separation on a wall or separation downstream of the base, followed by a reattachment of external and internal flows.

In conclusion he believed that present knowledge was too scrappy to enable a suitable solution of the propounded problems to be found; progress in this field is closely connected with advances in basic research on the boundary layer.

*

J. S. Alford discussed methods of improving compatibility of inlet duct and engine through adequate programming in the following areas;

1. Design of induction systems for good flow distribution.
2. Development of flow distributing devices.
3. Design of compressors to accept moderate distortion.

4. Matching of inlet duct flow distribution to engine requirements.

The speaker showed how an inlet flow distortion index was developed from the proposition that the effect of circumferential variations of total pressure on engine stall margin was proportional to the magnitude of distortion, and to the number of stages over which the distortion persisted. This distortion index was used to correlate the effects of circumferential variations of inflow total pressure on the steady-state stall margin of jet engines having multi-stage axial compressors.

● Dynamics of Flight

Chairman : Dr. W. Cawood, Director General of Scientfic Research (Air), Ministry of Supply, U.K.

Lecturers : Dr. Lee Arnold of the Institute of Air Flight Structures, Columbia University, N.Y. (U.S.A.) : — " Aeroelastic effects on dynamic behaviour of aircraft ".

Richard R. Heppe, Head of Aerodynamics Department, Lockheed Aircraft Corporation, California Division (U.S.A.): — " The role of dynamic analysis in the design and development of aircraft ".

H. P. Whitaker, Deputy Associate Director in the Instrumentation Laboratory, M.I.T. (U.S.A.); Dr. R. C. Seamans, Director of the Airborne Systems Laboratory of R.C.A., M.I.T. (U.S.A.); M. J. Bicknell, Associate Professor of Aeronautical Engineering, M.I.T. (U.S.A.); E. E. Larrabee, Assistant Professor of Aeronautical Engineering, M.I.T. (U.S.A.): — Subject " Automatic control of aircraft ".

Ciampolini and Provero, engineers from the Fiat works, Turin:—" Mechanical reducing and computing of flight test data ".

*

Richard R. Heppe described the role which dynamic techniques play in the design and development of aircraft; flying characteristics of modern configurations display types of motion not previously encountered and require the application of new analytical and experimental techniques to gain design insight. Modern high speed computing equipment is capable of solution of the complex mathematical statements required, and excellent correlation with actual flight data establishes the accuracy of such techniques. Typical results in the areas of flying characteristics, aeroelasticity, loads, automatic controls and aircraft performance show the impact of dynamic analysis upon aircraft configuration selection and emphasize the necessity for application of such techniques in the earliest stages of design developments.

*

Bicknell, Larrabee, Seamans and **Whitaker:** the evolution of modern high performance aircraft has increased the complexity and accuracy requirements of the aircraft control process to the extent that a human pilot is unable to cope with certain flight situations. This problem has led to the development of automatic flight control systems, which are rapidly becoming integral parts of the completed aircraft and are as essential to its operation as the airframe and propulsion system.

*

Ciampolini and **Provero** described Fiat methods and equipment for mechanical reducing and computing of flight test data, and three particular problems were analysed.

● Axial Turbojet Aerodynamics

Chairmen : M. Wanner, Coordinateur des Recherches scientifiques et techniques à la D.T.I. (Ministère de l'Air) and M. Jarry, Président de l'A.F.I.T.A.

Lecturers : Frank E. Marble, Associate Professor, California Institute of Technology, U.S.A., and W. Duncan Rannie of the Daniel and Florence Guggenheim Jet Propulsion Laboratory, U.S.A.:— " Unsteady flows in axial turbomachines ".

Prof. H. Söhngen, Darmstadt Institute of Technology and Prof. A. W. Quick, Director of the Deutsche Versuchsanstalt für Luftfahrt, Aachen:— " Variations in axial compressors ".

A. D. S. Carter of the National Gas Turbine Establishment, Pyestock, U.K.:—" The post-war development of the axial compressor in Great Britain ".

R. Siestrunck, Divisional Chief; J. Fabri, Group Chief; L. Jarlan, Research Engineer; of O.N.E.R.A.: —" Study of the critical unsteady conditions in aircraft compressors running at reduced speeds ".

Prof. P. Ruden of Messerschmitt A.G., Munich: —" Biparametric classification of plane cascades according to their global effect, and application to cascades for high speeds ".

*

Frank E. Marble and **W. Duncan Rannie** dealt with the various unsteady flows which occur in axial turbomachines and discussed how certain asymmetric disturbances have become understood to some extent. A special type of propagating stall appears as a self-induced oscillation; an asymmetric velocity profile introduced at the compressor inlet constitutes a forced oscillation. For the self-induced disturbances and the more interesting examples of the forced disturbances, the dominant blade characteristic is the dependence of total pressure loss, rather than the turning angle, upon the local blade inlet angle.

*

H. Söhngen and **A. W. Quick** pointed out that in considering and explaining the vibrational phenomena of axial compressors, the very important role played by gas compressibility must be taken into account. Contrary to the case for the single airfoil, the explanation here remains valid as the steady flow velocities are diminished to small values. The natural vibrations of the gas which can arise in the circular ducts, and which have the same vibration modes as the turbine blading, are responsible for this phenomenon. When the natural frequencies of both gas and blades coincide, which can easily be brought about, for example, by careful selection of the speed of rotation, the blades vibrate without aerodynamic damping. Natural vibrations of the gas can be generated by separation phenomena; these then set the blades into vibration.

*

A. D. S. Carter stated that after a period of optimism which pervaded every outlook and was fostered by the outstanding success of the axial compressor at that time, further developments led to the first real problem—that associated with badly shaped surge lines—and required a more critical review of the fundamental knowledge of flow in the machine. The empirical nature of this knowledge was emphasized and formed the basis for subsequent development, the most significant factor probably being the actuator disc theory. In conclusion the speaker commented that although academically the position is depressing, empirical knowledge has reached a stage where the future can be looked to with confidence.

*

R. Siestrunck, J. Fabri and **L. Jarlan** commented on the fact that axial compressors have become less and less suitable for off-design operation and that their functioning is sometimes even dangerous; spectacular breakdowns have occurred during the ground test runs of the latest type jets at various engine firms, and the technicians have been led to study more closely the fundamental aerodynamic and aeroelastic phenomena in axial compressors during off-design operation. The most dangerous of these phenomena is the rotating stall in the first stages of multi-stage compressors at low speeds. The main purpose of the paper presented was to describe this type of flow instability and its effect.

By means of visualisation or hot-wire recording in the engine, a picture can be obtained of the rotating stall as a uniform propagation around the compressor axis, of stalled cells, made up of nearly dead fluid, where no through flow is possible. These stall cells have a throttling effect on the main flow which, outside of the stall regions, retains the behaviour of a perfect flow. The phenomena appear at high angles of attack and particularly in the first stages of multi-stage compressors at low r.p.m. The number, extent and speed of rotation of the stall cells can be measured by several methods. As a first approximation the stall configurations depend on the usual similarity parameters of compressor operation, and their speed of rotation is proportional to that of the compressor, at least for stall patterns of a given type.

*

Prof. P. Ruden proposed a new plane cascade theory, whereby it is possible to determine the speed distribution on the profile of a given geometry cascade and the global cascade effect (flow deflection, pressure rise, etc.) as a function of the angle of incidence.

The problem, at first appearing very difficult, of designing a technically useful cascade from the parameters β and δ can also be solved, as was shown by several examples. The calculated cascades not only develop the prescribed global performances in the whole range of incidence angles, but they also meet other requirements to which high speed cascade profiles are submitted.

*

The above review of the fourteen papers presented to the Congress contains merely the most important points brought out in the very significant and wide-ranging themes. I have, however, attempted to give a short general review of each of the papers presented.[1]

*

In conclusion I should also like to refer to two further events which are specially noteworthy:—

During this Congress, the representatives of the aeronautical sciences of ten countries (U.S.A., Great Britain, Canada, Germany, Holland, Italy, Spain, Sweden, Switzerland, and France) met and jointly agreed to the foundation of the " Congrès International des Sciences Aéronautiques " (C.I.S.A.), the first session of which is planned for the late summer of 1958 in Madrid. The provisional committee, which was presided over by Dr. Th. von Karman, set up an Executive Board which proceeded to elect Prof. M. Roy as Chairman.

Another meeting, under the Chairmanship of J. Jarry, was attended by the representatives of the ten continental European member nations of the " Congrès Aéronautique Européen " (C.A.E. was founded by A.F.I.T.A. and is under the patronage of the Association Internationale des Constructeurs de Matériel Aéronautique—A.I.C.M.A.). The ten member countries were represented by: Quick (Germany), Kirste (Austria), Haus (Belgium), Jarry (France), van Meerten (Holland), Pistolesi (Italy), Wänström (Sweden), Dechevrens (Switzerland), Nenadovitsch (Yugoslavia), and Soriano (Spain). The delegates unanimously agreed to form themselves into a permanent committee under the chairmanship of J. Jarry with a secretariat to be provided by A.F.I.T.A.

[1] Further information regarding the publication of the complete texts of the lectures may be obtained from:—A.F.I.T.A., 6 rue Cimarosa, Paris 16e, or from O.N.E.R.A., 29 Av. de la Division Leclerc à Chatillon-S/Bagneux (Seine), France.

Book Reviews

L'Aviation nouvelle. — Edited by Camille Rougeron, published by Larousse, Paris, 1957 (French; 448 pages; 96 black-and-white illustrations, 16 full-colour photos; price 2,800 francs).

The presentation of technical information in popular form is always a difficult task. So many technical experts have neither the desire nor the gift to hold the reader's interest through attractive style and simple reasoning. And brilliant writers frequently do not do justice to their subject matter.

It is therefore refreshing to find that the French publishing firm of Larousse has collected together a team of first-class aeronautical specialists, headed by the well-known military writer Camille Rougeron, who have produced what is in many respects a pioneering volume. The method of presentation used for this introduction to modern aviation is commensurate with the subject. The well-worn track traditionally followed by encyclopaedias, with their historical ballast, has deliberately been avoided, and " Aviation Nouvelle " takes the reader straight to the aviation of 1957. Selected articles and their authors: " Aeronautical Research " by M. Roy, member of the Académie des Sciences and Director of O.N.E.R.A.; " Airframes and their Configurations " by J.-Ch. Parot, Chief Engineer, Sud-Aviation; " Tactical Missions " and " Strategic Missions " by C. Rougeron; " Naval Aviation and Aircraft Carriers " by Vice-Admiral P. Barjot; " Air Transport " by F. Serraz, etc. All in all, a book calculated to win many a convert to aviation. He.

Die Entwicklung des Weltluftverkehrs (supplementary report for 1957) and **Die zivile Luftfahrtpolitik der Vereinigten Staaten von Amerika.** — By Prof. Edgar Rössger. No. 417 in the series of research reports issued by the North Rhine-Westphalia Ministry of Economy and Transport.—Westdeutscher Verlag, Cologne and Opladen, 1957 (German; printed in manuscript form; 220 pages; price DM 48.—).

In 1955 the North Rhine-Westphalia Ministry of Economy and Transport undertook the complex and lengthy task of *analysing the development of air transport since World War II and clarifying its guiding principles*, so as to assist Germany's reactivated air transport industry in finding its way back into the international field. The first report published under this programme was No. 195 " Gedanken über einen neuen deutschen Luftverkehr ", by Prof. Rössger, and the present report No. 417 is the *first* supplement, which is to be followed by others as the occasion arises (a continuation of the series is planned for early 1958).

The benefits of this painstaking research, however, will by no means be restricted to German air transport. A study of Report No. 417 reveals clearly that air transport experts in all countries owe a debt of gratitude to Prof. Leo Brandt, editor of the series, particularly for the second part of the report, on the United States' civil aviation policies. No European airline can operate successfully without full and reliable information on the background and aims of American air transport policy. Professor Rössger's treatise provides this information in exemplary form. He.

Rocket. — By Air Chief Marshal Sir Philip Joubert de la Ferté. — Hutchinson & Co. (Publishers) Ltd., 178-202 Great Portland Street, London, W.1, 1957 (English, 190 pages, 18s.).

The most fascinating part of this book by one of the R.A.F.'s best-known historians and former officers deals with the German V-weapons menace in World War II. It describes the way in which the Allies gradually became aware that something was " cooking ", how evidence on the German V1 and V2 programmes was slowly gathered from the underground in occupied Europe and neutral countries, how counter-measures were organized —the gruelling attack on Peenemünde, for example, the tedious destruction of launching ramps, etc. At its beginning the book outlines the development of rocketry through the centuries, in the latter part it traces the effect which rockets and missiles are having on modern strategy and tactics, with particular reference to the defence of Europe within N.A.T.O. Ed.

British Plastics Year Book 1957. — Iliffe & Sons Ltd., London, 1957 (English ; 716 pages ; price 42 shillings).

The 27th edition of this annual reference book to the British plastics industry once again follows the traditional arrangement. A lengthy introductory chapter summarizes recent patents in all fields of plastics chemistry, and is followed by lists of manufacturers classified according to raw materials and manufactured products, makers of plant and equipment for the industry. Next comes a list of proprietary names and technical terms, the names and addresses of roughly 4,000 firms and a Who's Who of the British plastic industry. Re.

Jahrbuch 1956 der Wissenschaftlichen Gesellschaft für Luftfahrt (W.G.L.). — Edited by Professor H. Blenk; compiled by Werner Schulz; published by Verlag Friedr. Vieweg & Sohn, Brunswick, 1957 (German; 247+XIX pages; price DM 38.—).

As no W.G.L. Annual Meeting was held in 1956, this year's W.G.L. Yearbook contains the original versions or German translations of a number of lectures read at the joint W.G.L.-A.F.I.T.A. meetings held in Paris, Brunswick and Darmstadt, the Vienna Aeronautical Science Congress, the Munich Aircraft Noise Conference, a number of W.G.L. discussion evenings, etc. These contributions are supplemented by a number of W.G.L. prize essays and a summary of a doctor's thesis (K. H. Gronau). Of the total of 20 contributions, special mention can be made of the following five:—*F. Ferrié*, Paris " Re-starting Jet Engines at Altitude "; *H. Schlichting*, Brunswick " Suction in Aerodynamics "; *Ph. Poisson-Quinton*, Chatillon " Blown Wings "; *G. Bock*, Darmstadt " Flight at High Speeds "; *E. Koppe* and *E.-A. Müller*, Göttingen " Jet Noise ".—The last-mentioned, very thorough examination will undoubtedly arouse particularly widespread interest, as the subject is today very much on the public mind (the bibliography cites 87 references).—The Yearbook closes with an up-to-date list of W.G.L. members. Ri.

Aktivierung der Talente. — By Rheinhold Schairer. — Eugen Diederichs, Düsseldorf-Cologne, 1957 (German ; 151 pages).

An entertaining treatment of a subject which is causing industry in all countries lively concern at present, namely the question of filling future staff needs. The author does not speak in facts and figures, or put forward cold technical proposals for controlling labour or vocational advisory centres. Instead he makes an energetic appeal for the encouragement of young people, advocating on the way an understanding between East and West. He.

Propagation des Ondes Electromagnétiques de Haute Fréquence. — By J. Ortusi. — Société Française de Documentation Electronique, Paris, 1957 (French ; 320 pages : price 3,100 French francs).

One of the first French engineers to write on the propagation of high frequency energy opens with this book the " Collection des Annales de Radioélectricité ". He addresses engineers, technicians and students concerned with problems of HF wave propagation and devotes five chapters to electromagnetic energy, progressive guided waves, propagation in anisotropic media, waveguide branches and propagation around the earth's surface. Na.

Cours d'Aéronautique. — By C. R. Serane. — Dunod Ed., Paris, 1957 (French, XII+300 pages, 354 figures, 1,950 French francs).

The complete course in aeronautical engineering, here reproduced in simple, concise style, gives an excellent overall view of the general problems concerning modern aeronautical engineering. After an introduction to the mechanics of fluid flow, the author passes on ot aerodynamic tests and describes the various types of wind tunnel. The aerodynamic study of wings and high-lift devices leads him on to the whole aircraft. Next comes a discussion of the different types of power plant, the mechanics of flight and a chapter on aircraft performance, with logarithmic diagrams and practical methods of determining performance. A last chapter is devoted to the description and study of the functioning of various aircraft instruments. So.

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Cours de mécanique du vol. — By A. Turcat, S.N.C.A. du Nord Chief Test Pilot. — Dunod Ed., Paris, 1957 (French ; XII+148 pages, 130 illustrations : price 1,800 French francs).

This book by a Chief Test Pilot repeats the subject matter of a course of lectures read to the French Pilots and Engineers School and forms an excellent bridge between the theoretical scientist's more abstract writings and the often superficial manuals prepared by technicians. The author follows a line of strict reasoning based on simple calculations and has been careful to provide illustrations of each formula or equation he presents, thus making for simpler reading. The book will interest not only test pilots and engineers, but also research and development engineers, who will gain from it an insight into the test pilot's point of view, and to military, commercial and private pilots, who can thus broaden their study of the conditions of flight. So.

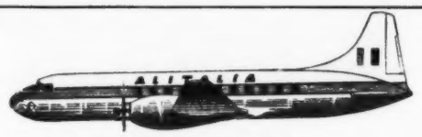
Translations

Le Temps d'Hier, d'Aujourd'hui, de Demain. — Translated and adapted from the original English " The Weather ", by G. Kimble, American Geographical Society (Penguin Books Ltd., Harmondsworth) by J. and M. Gauzit. — Dunod Ed., Paris, 1957 (French ; VIII+258 pages, 21 figures and 16 plates : 950 French francs).

Written primarily for the general public, this book presents in simple, direct fashion the complex problems involved in weather forecasting, the continuing, but slow, development of this science—due principally to the influence of air navigation, and its present capabilities. The statistics in the original book, which dealt with the English climate, have been replaced in the French edition by corresponding French statistics. So.

Mein Weg zu den Sternen (The Stars at Noon). — By Jacqueline Cochran (translated by Dr. R. Frank). — Verlag Albert Müller, Zurich, 1957, (German ; 219 pages).

An outstandingly courageous and charming American woman here relates in simple terms her astonishing life story, which led her from the most poverty-stricken surroundings (" I had no shoes until I was eight years old ") via a series of jobs as domestic servant, hairdresser's assistant, beauty specialist, to independence and a passion for flying. The high spots of her flying career include pre-war air races, her appointment as head of the Women's Air Force Service Pilots during the war and finally—in 1953—the first supersonic flight to be made by a woman, at the controls of a Canadair *Sabre*. Ri.



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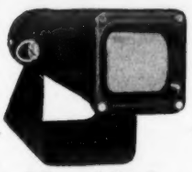
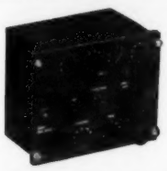


7.62 cm display for instrument panel mounting.



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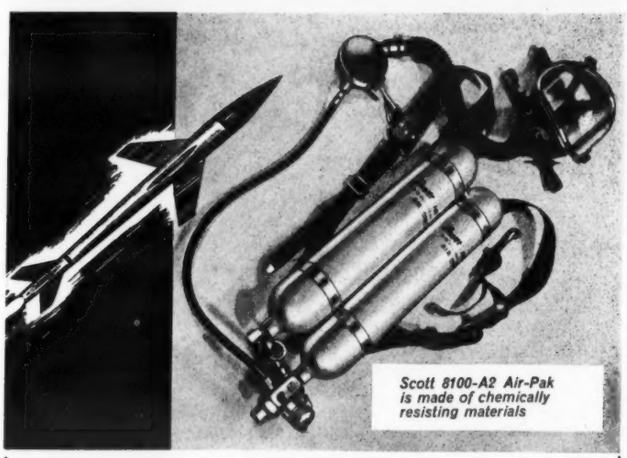

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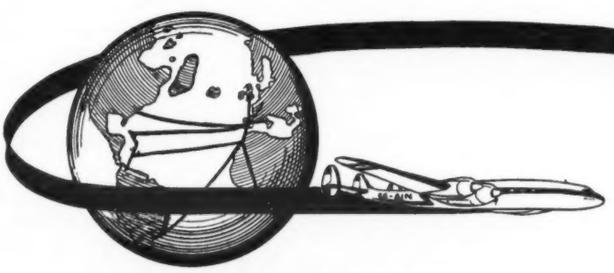

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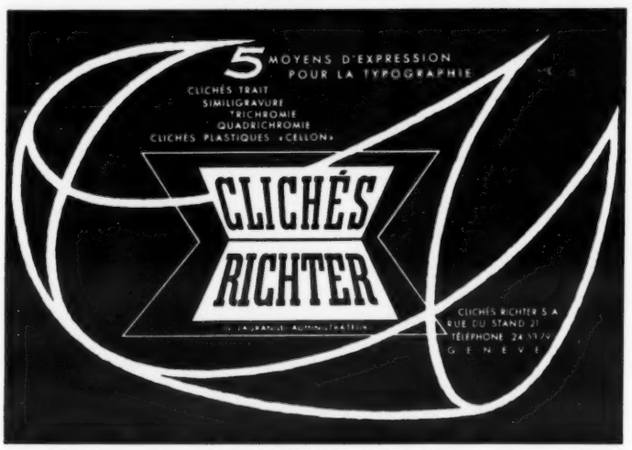

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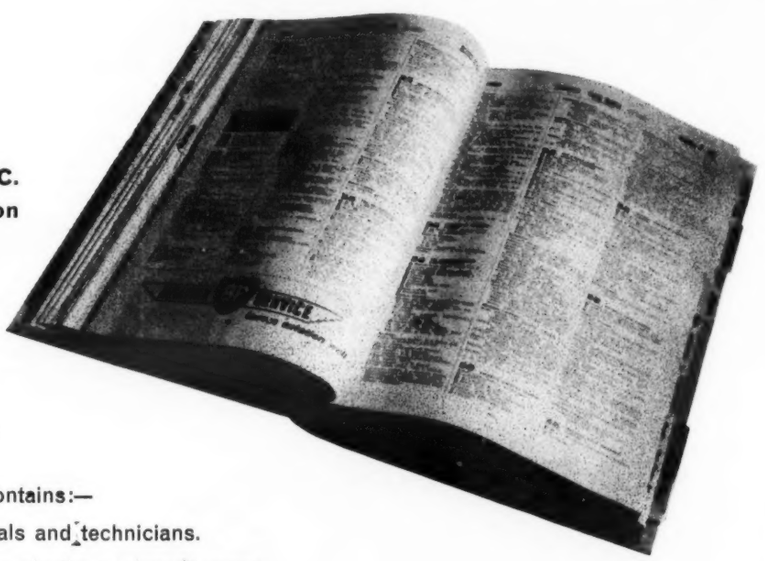

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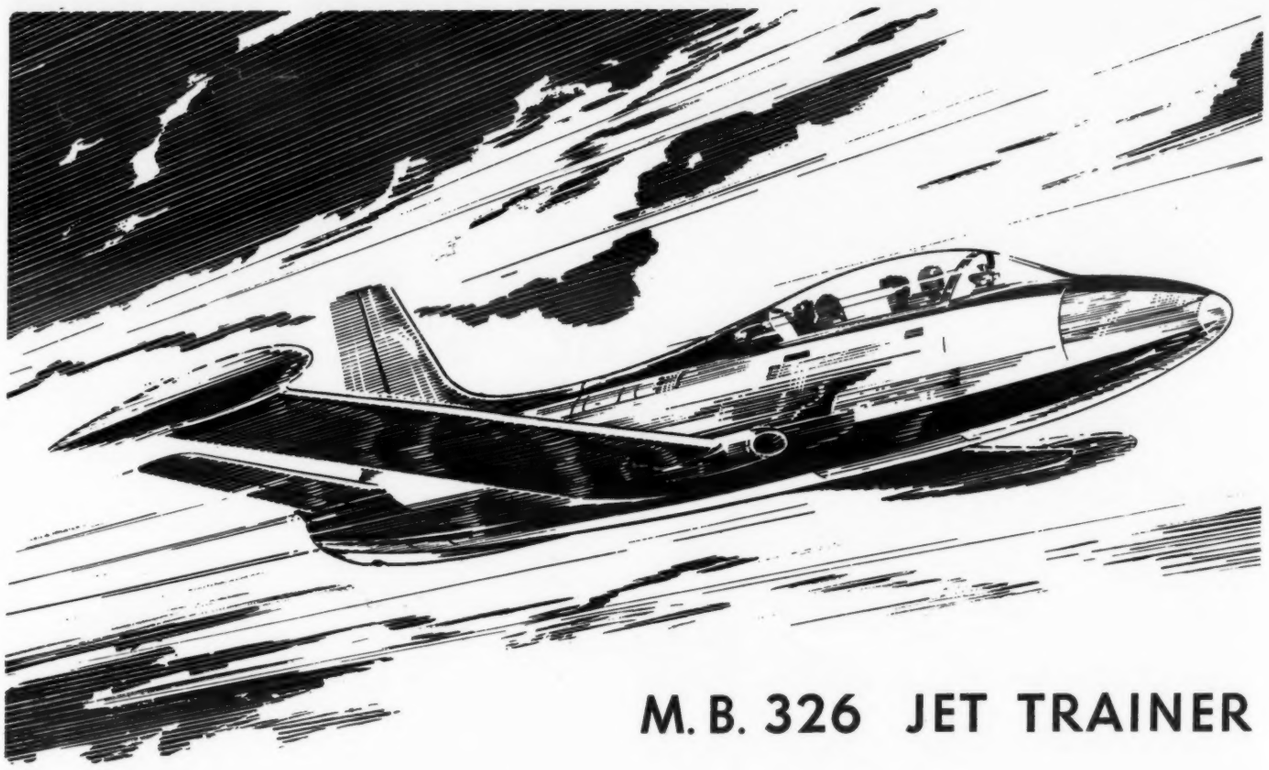

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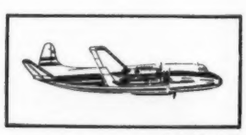

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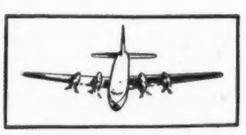

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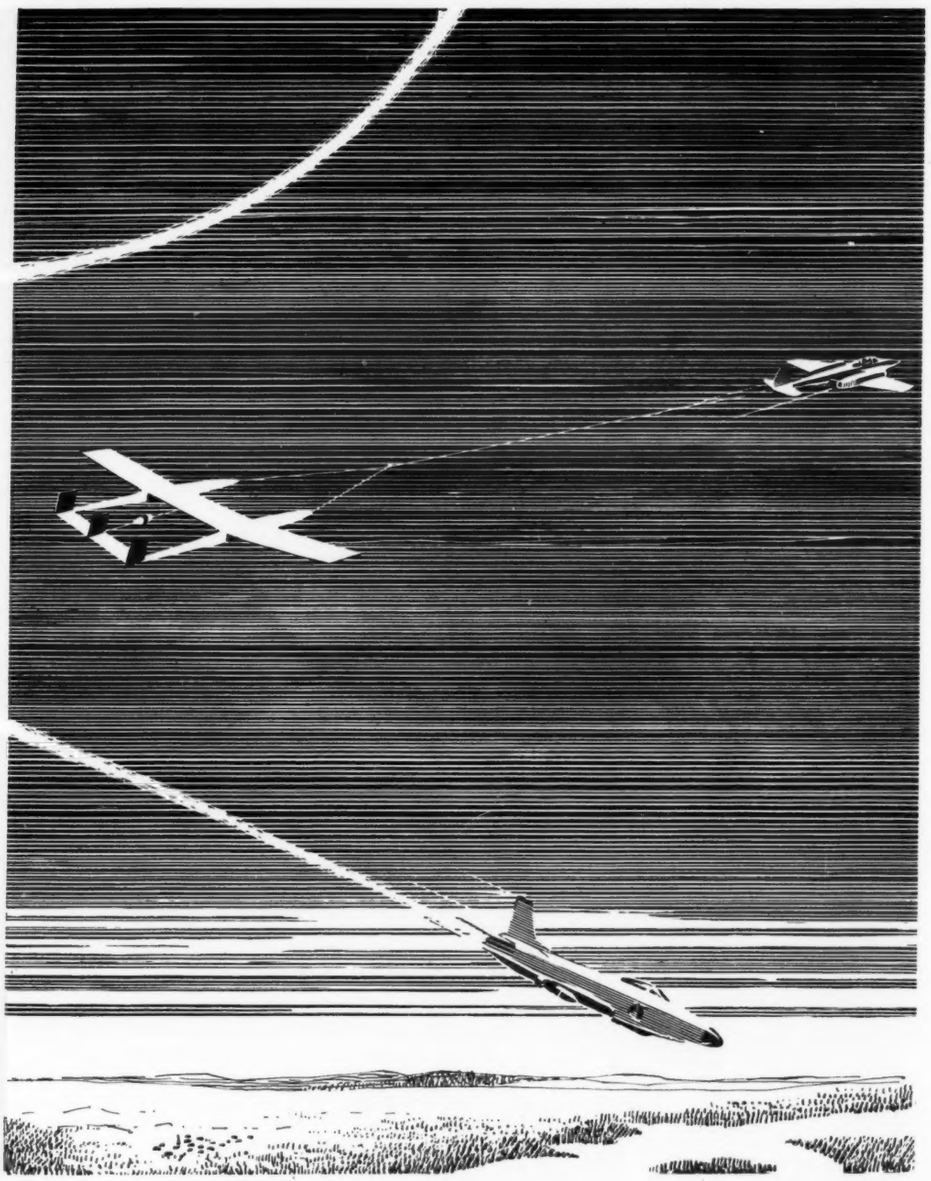

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